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Life Cycles
(Level 2)

Teacher's Guide

Robert Knott
Chester A. Lawson
Robert Karplus
Herbert D. Thier
Marshall Montgomery

RAND McNALLY
SCIS

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Preface: From SCIS to SCIIS

Over the past twenty years almost a hundred curriculum projects—the majority in science—germinated on the educational landscape. Some withered, some bloomed, and some not only thrived but went on to propagate successful offspring. Among the latter has been the Science Curriculum Improvement Study (SCIS), which grew out of Robert Karplus's early studies of elementary school children and science learning in the 1960s. Funded by the National Science Foundation, and eventually housed at the Lawrence Hall of Science, University of California at Berkeley, the SCIS program became one of several curriculum projects that have markedly changed the direction of elementary science education in the 1970s. After extensive testing with thousands of students and teachers, the first commercial edition of SCIS was published by Rand McNally in 1970–72.

The educational impact and acceptance of SCIS was rapid and widespread. The insights, commitment, and enthusiasm of the SCIS developers were passed on to the teachers using the program—directly and through workshops, in-service training, and visitation programs at the Lawrence Hall. These efforts were significantly reinforced by the publisher, who sponsored additional programs for teachers, set up information and awareness centers, provided consultants, and serviced thousands of schools with its representatives. In less than three years SCIS clearly established itself as a program to emulate. No other available materials provided science educators with so much flexibility in subject matter, classroom materials, and teaching strategy, within a clearly defined conceptual framework. No other program so explicitly set scientific literacy as its overall goal for children—and then earned the documentation (mostly from independent sources) to show achievement of that goal. No other program introduced children to the life sciences by bringing live organisms into the elementary classroom for direct observation and study. And no other program that focused on *doing,* rather than reading about, science was more widely adopted and used in the schools.

For these reasons, SCIS has been a challenging program and, at the same time, one that has been a pleasure to teach and to learn from. The challenge lay in the need for the developers, the publisher, and teachers to give something more in terms of time and effort, and to effectively create, deliver, and present to students the concepts and activities embodied in SCIS. For example, one of the salient and essential features of the program is the presence of live organisms in the classroom; the culturing, scheduling, procurement, use, care, and maintenance of selected plants and animals, no matter how hardy, required a commitment over and above that needed in a "read-about" science program.

On the other hand, that SCIS has been a pleasure to teach is a judgment that comes from thousands of educators and children who have used it. An overwhelming majority have told the publisher and the authors that student interest, enthusiasm, and achievement have been markedly increased in their classes—and not only in terms of science. Language and communication skills have improved, as supported by research. Ability and willingness to observe, measure, collect data, organize information, reason, interpret, and weigh evidence have been characteristic of SCIS learners. Anticipating and then witnessing these outcomes in the classroom helps to make teaching what it at least occasionally needs to be—a joyful experience.

During the 1975–76 school year Rand McNally invited approximately 500 elementary specialists and teachers using SCIS in a wide variety of locations and educational environments to review the materials and comment critically from their own experiences. They did so in person and in writing, and the resulting feedback has provided a basis for thorough revision by members of the original SCIS author team. Working together, the authors and the publisher began developing the new program you now have in hand. The task encompassed far more than merely remodeling the existing activities, books, and equipment. New activities, concepts, themes, learning components, design, packaging, sources of supply, delivery systems, and services to support teachers — these and other features of the new program were scrutinized and tested in schools or laboratories, and measured against the expressed needs of the schools.

The end result is the Rand McNally SCIIS program.

We are pleased with it. We are confident that it will provide you and your students with even greater opportunities for learning and enjoyment in science—and in ways related to other disciplines—than did its predecessor. And we want to hear from you about your experiences with it (see the Evaluation Response Form, drawer 1, in the kit).

Finally, our thanks to the many teachers, parents, and children who voluntarily give us the benefit of their comments. We would like the reader to join them—as a user and as a friendly critic—in the ongoing task of improving science education, with SCIIS.

A note about the title and logo

We seem to be nearing a time when the supply of possible acronyms for educational programs, projects, and organizations will be exhausted. Rather than contribute to a further drain on the supply, we thought it singularly appropriate to retain much of what "SCIS" has been—in name as well as in substance. We saw the task as one of improving SCIS *from within* a conceptual and physical framework that had already proven itself in the classroom, rather than simply adding on from outside or giving the impression that we were starting from scratch again. Hence, SCIS became SCIIS, with another I inserted. And something resembling the original "snowflake" survives in the logo.

For the literal-minded, the new I may serve to represent further improvement, or more innovation, or (with its partner) a two (II). Thinking about and debating such fine points provided hours of recreation for editors, advertising staff, and project management. We would prefer that you call the program "Rand McNally SCIIS" to avoid confusion with the earlier SCIS or with other products now using a similar name.

For the Authors—
Herbert D. Thier

For Rand McNally—
William Miller

August, 1977

An Introduction to SCIIS

The Conceptual Framework

Diversity and change—in the landscape, in cloud formations, at the zoo, in a jar of sugar water forming rock candy—attract children's attention and awaken their interest. Curious about their surroundings, children naturally seek to describe and sort the diverse animals, plants, and nonliving materials they discover. In this respect they resemble scientists, who try to understand the basic conditions governing change.

THE GOAL: SCIENTIFIC LITERACY

Through investigation, scientists' understanding of nature advances from simple hypotheses to complex theories. Similarly, children's thinking advances from the concrete to the abstract as they accumulate experiences and ideas. They develop more effective techniques for observing and testing nature. In other words *they become scientifically literate*.

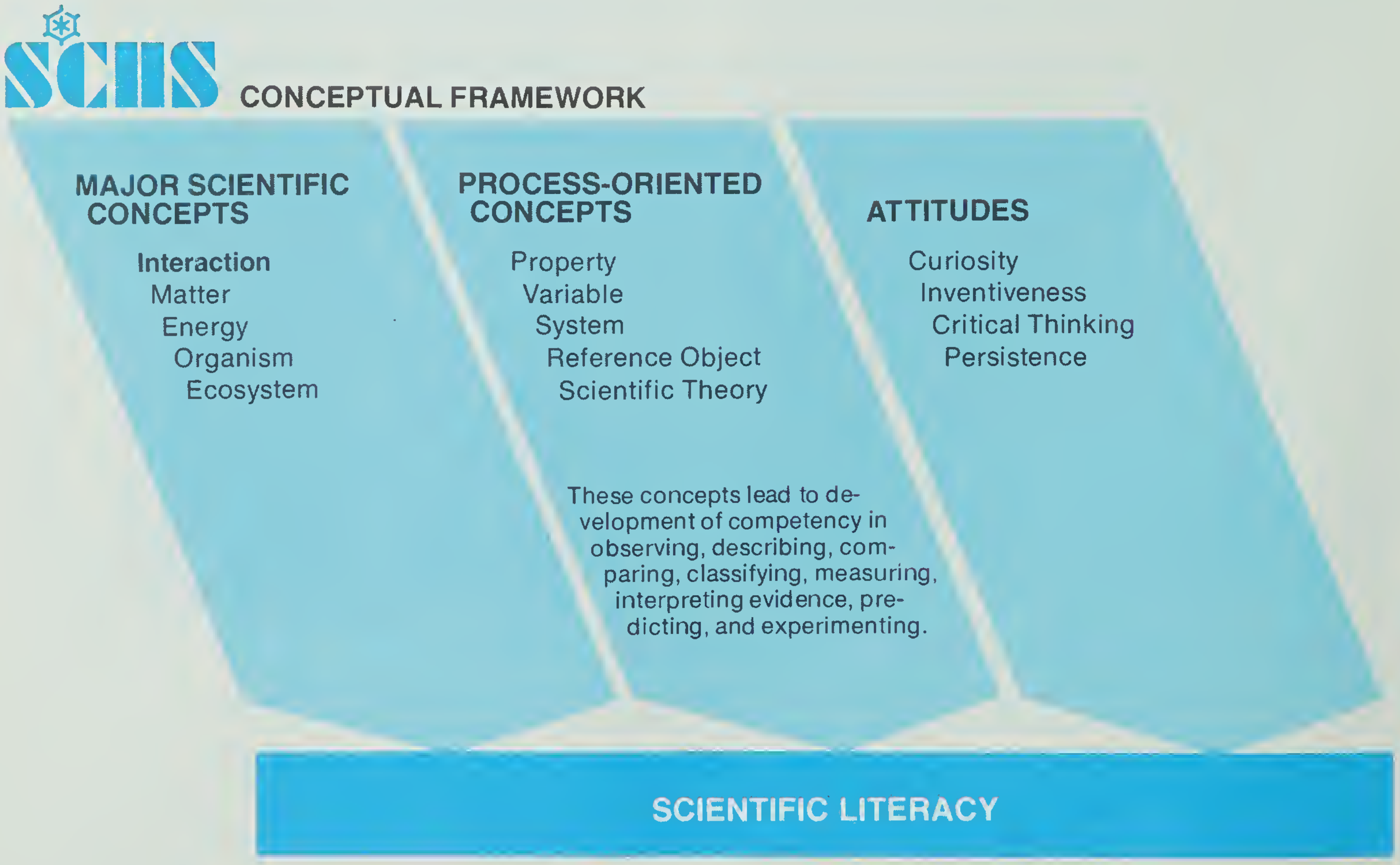
Scientific literacy derives from basic knowledge, investigative experience, and curiosity. In the SCIIS program, these three factors are integrated, balanced, and developed through the children's involvement with basic scientific concepts, process-oriented concepts, and challenging problems for investigation.

CONCEPTS, PROCESSES, AND ATTITUDES

Educators frequently distinguish among content learning, process development, and attitude formation when they describe an educational program or evaluate its outcomes. The SCIIS program combines these three factors into an integrated whole, matching the way children learn. Children are introduced to scientific content through firsthand experiences—with magnets, gears, fish, crickets, and a wide range of other living and nonliving materials.

In the course of their investigations, children engage in observation, measurement, interpretation, prediction, and other processes essential for the development of scientific literacy.

Finally, the SCIIS program helps children form positive attitudes toward science as they explore phe-



SCIIS CONCEPTUAL FRAMEWORK

MAJOR SCIENTIFIC CONCEPTS

Interaction
Matter
Energy
Organism
Ecosystem

PROCESS-ORIENTED CONCEPTS

Property
Variable
System
Reference Object
Scientific Theory

ATTITUDES

Curiosity
Inventiveness
Critical Thinking
Persistence

These concepts lead to development of competency in observing, describing, comparing, classifying, measuring, interpreting evidence, predicting, and experimenting.

SCIENTIFIC LITERACY

nomena. Using their own ideas and preferences, children learn to cope confidently with new and unexpected findings by sifting evidence and forming conclusions—thus removing the "magic" from science.

Major Scientific Concepts *Interaction.* The concept of *interaction* is central to modern science—and therefore also to the SCIIS program. This concept embodies the scientific view that changes in nature take place because objects interact in reproducible ways when conditions are controlled. In the scientific view, changes do not occur because they are preordained or because a "spirit" or other power within objects influences them capriciously.

When objects or organisms do something to one another that brings about a change, we say that an interaction has occurred. When you clap your hands, they interact with one another and the air. The observed changes, the sensation in your palms, and the sudden sound are evidence of interaction.

Children can easily observe and use such evidence. They can watch a guppy eat a daphnia, hear bubbles when seltzer tablets dissolve, spin a compass pointer with a magnet, and detect the odor of decomposing organic materials. As they advance from dependence on concrete experiences to the ability to think abstractly, children can identify the conditions under which interactions occur and predict their outcomes.

In SCIIS, four major scientific concepts elaborate the interaction theme—*matter, energy, organism,* and *ecosystem*. Children's experiences and investigations in the six units that make up the physical/earth science sequence are based on matter and energy.

Organism and ecosystem provide the framework for the six units in the life/earth science sequence. Additional concepts are described in the appropriate Teacher's Guides.

Matter. Matter, or material, is introduced in the SCIIS program through the solids, liquids, and gases in the environment. These interact with human sense organs and with each other. Material objects can be described and recognized by their color, shape, weight, texture, and other properties. As children investigate changes in objects in the SCIIS physical/earth science sequence, they become aware of the diversity of interacting objects and their properties.

Energy. Energy is the inherent ability of a system to bring about changes in itself or in the state of its surroundings. Some familiar energy sources are the natural gas used to heat a kettle of water, the horse used to pull a plow, the unwinding spring that operates a clock, and the discharging battery in a pocket radio. The complement of an energy source is an energy receiver, such as the football kicked by a player or the ice cube placed in warm water. The interaction between energy source and receiver results in energy transfer.

Organism. An organism is an entire living individual—plant or animal. It is composed of matter, and it uses the energy from its food to develop, grow, and be active. The organism concept represents a fusion of the matter and energy concepts, but it is much broader than the sum of its parts. An essential factor is the organization of matter into cells and other structures that assure continuity of life from generation to generation.

Ecosystem. Awareness of the interactions between organisms and the environment leads to the ecosystem concept. As children observe living plants and animals in the classroom or out-of-doors, they notice the amazing diversity of organisms and their life cycles. They observe how plants and animals interact with one another and with the soil, atmosphere, and sunlight in the complex network of relationships that constitute an ecosystem.

Think of a forest as an example. A forest is more than an assemblage of trees. Living in the shade of trees are shrubs, vines, herbs, ferns, mosses, and toadstools. Dependent upon these plants and living among them are insects, birds, mammals, reptiles, and amphibians. The animals depend on plants for food, shelter, and other needs. The plants use sunlight, carbon dioxide, water, and minerals to make food that sustains themselves and other organisms in the forest.

Process-Oriented Concepts. By defining and emphasizing specific concepts, SCIIS permits teachers and pupils to concentrate on the objectives of the program. Five process-oriented concepts—*property* (or characteristic), *variable, system, reference object,* and *scientific theory*—underlie and are essential for development of competency in the processes of observing, describing, comparing, classifying, measuring, interpreting evidence, predicting, and experimenting.

Property. We have already referred to the properties by which an object may be described or recognized. A property is any quality that enables you to describe, compare, or classify objects. Color, size, shape, texture, and scent are properties of a blossoming plant; color, density, and hardness are properties of a mineral specimen; and size, color, and style are properties of a suit of clothes.

Properties also enable you to describe concepts. For example, duration is a property of a time interval; accuracy is a property of a carefully-made measurement; and the term climate (hot, cold, temperate) summarizes the properties of weather in a specific region.

Variable. Properties and conditions that differ from one experiment to another are important in scientific work, and they have been given a special name—variables. Examples are the temperature of water being warmed by the sun, the amount of fertilizer added to a potted ivy plant, the length of time a flashlight battery has been used, and the number of crickets feeding on a particular patch of grass.

System. System is a word that has entered everyone's vocabulary. We deal with the nervous system, communications systems, electronic systems, and systems analysis. In all of these a system is a whole made up of related parts. Earth and its moon form a system of two closely interacting bodies in space. A seed, moist soil in which it is planted, and air form a system. The system concept reflects the fact that objects and organisms do not function in isolation but exist in a context of interaction with other objects or organisms.

When one system is part of another system, it is called a *subsystem*. The earth, including its atmosphere, plants, and animals, is a subsystem of the earth-moon system. The seed, with its embryo, seed coat, and stored food, is a subsystem of the seed-soil-air system.

The terms object, subsystem, and system allow us to use three levels for grouping the elements that attract our attention in an event. We shall use the word "object" for individual pieces of matter, "subsystem" for intermediate groups of objects, and "system" for the largest collection under consideration.

We have concentrated on "closed" systems in the SCIIS physical/earth science sequence. A closed system is defined by the matter of which it is composed. Whenever matter is added to, removed from, or replaced by, other matter, the original system becomes a new system. When nothing is added or removed, a system retains its identity even though it may change in form or appearance.

Sometimes (especially in the life sciences) scientists find it useful to work with "open" systems, which are defined by the matter occupying a certain region of space. The air space within a terrarium is an example. In an open system there may be changes of matter without changes in identity—as when water vapor, carbon dioxide, and oxygen enter and leave the air even though the terrarium is covered. The ecosystems children investigate in Level 6 are examples of open systems. Children who continue to study science may learn to distinguish between open and closed systems when that distinction becomes important.

Reference object. The fourth process-oriented concept, reference object, helps children overcome the limitations of describing position and motion only from their own point of view. Space exploration has shown that we can no longer think exclusively in terms of up-down and north-south as defined on the earth. For young children—who at first relate objects only to themselves—the use of external reference objects is a challenge.

In SCIIS, the basic concept is simple: Position and motion of objects can be described only with reference to other objects, including (possibly) the body of the observer. When you say, "Meet me at the north end of the picnic area," you describe the location of the meeting place relative to the picnic area. In the example, the picnic area serves as reference object and the compass direction serves as reference direction. When you say, "The main entrance to the museum is to your left," you are using the listener's body as reference object.

The child who can take into account several reference objects and reference directions overcomes a spatially self-centered viewpoint. The concept of the earth as a sphere in space can be understood only in relation to a reference object not located on the earth itself; therefore an understanding of reference objects is fundamental to further work in earth and space sciences.

Scientific theory. An example of a scientific theory is the ray theory of light, which holds that light consists of rays propagating from a lamp or other light source to your eye or an illuminated object.

An everyday example of theory-building can be derived from a look at a common pay phone. How does the coin turn on the phone connection? One might imagine that the coin falls on and depresses a small platform, thereby closing a switch. What is your theory of how the coin turns on the telephone? Keep in mind that many phones work with a dime but not with a nickel, or with two dimes but not with three nickels, even though a nickel is heavier than a dime.

Scientific theories provide explanations for natural phenomena such as light, photosynthesis, weather, heredity, chemical combination, or the solar system. A theory usually postulates certain unseen relationships or objects, such as light rays emanating from a lamp, the platform in a telephone, or atoms in a material substance. Theories also lead to predictions and new discoveries about the events being investigated. If the predictions are not borne out, a theory may be discarded. By using scientific theories, children can relate present observations to previous and subsequent experiences with similar events.

Structure and Content

The SCIIS program consists of thirteen learning units in science for children at preschool, kindergarten, and elementary school levels. The introductory unit, *Beginnings*, leads into two six-unit sequences—the physical/earth science sequence and the life/earth science sequence.

The two sequences are complementary in that either of the two units for any one level may be used first. For example, at Level 1 you may use *Material Objects* in the fall and *Organisms* in the spring, or vice versa. This flexibility permits switching of units between two classes at midyear. (Supplementary and alternate packages of materials are available for schools wishing to switch units, to share unit kits among two or more classes, or to supply exceptionally small or large classes.)

The physical/earth science sequence guides children through carefully selected investigations of the physical world. In the same way, the life/earth science sequence focuses attention on the biological world. Both sequences include treatment of some topics relating to the earth sciences—shadow astronomy, map coordinates, water and mineral cycles, and climatic factors are examples.

SYNOPSES OF THE UNITS

Concepts and processes developed and emphasized throughout the SCIIS program have been described in the preceding "Conceptual Framework." The following summaries list the concepts and processes most important within each unit.

Level K *Beginnings*

Concepts and processes emphasized in this unit: color, shape, texture, odor, sound, size, quantity, position, organism.

The *Beginnings* unit for kindergarten and early childhood education offers a wide variety of activities and experiences in both life and physical sciences. Most of the activities are designed for use in small-group learning situations. Children learn to observe, discriminate, and describe, using objects and organisms in the classroom and outdoors. These early experiences help them develop language and participation skills and contribute to their growing understanding of science. The *Beginnings* unit leads into the physical/earth science and life/earth science sequences.

SCIIS STRUCTURE AND SEQUENCE OF UNITS

	Physical/Earth Science Sequence	Life/Earth Science Sequence
K	BEGINNINGS	
1	MATERIAL OBJECTS	ORGANISMS
2	INTERACTION AND SYSTEMS	LIFE CYCLES
3	SUBSYSTEMS AND VARIABLES	POPULATIONS
4	RELATIVE POSITION AND MOTION	ENVIRONMENTS
5	ENERGY SOURCES	COMMUNITIES
6	SCIENTIFIC THEORIES	ECOSYSTEMS

Physical/Earth Science Sequence

Level 1 *Material Objects*

Concepts and processes emphasized in this unit: object, property, material, serial ordering, evidence.

The children handle, observe, and describe objects. They learn that objects are composed of materials and have properties by which the objects can be discriminated; that some objects are solids, while others are liquids or gases; that objects can change; and that there are ways to recognize evidence of change. Property comparison leads to the concept of serial ordering. As the children investigate the properties of various materials, they realize that the same substance can exist in more than one form, and they gain an awareness of the principle of conservation of matter.

Level 2 *Interaction and Systems*

Concepts and processes emphasized in this unit: interaction, system, evidence of interaction, interaction at a distance.

The concept of interaction is introduced, as well as the concept that related objects or parts comprise a system. Students examine a variety of interactions, some of which are directly observable, others less apparent. The evidence that an interaction has taken place comes from the observed change in the system. The children investigate gear/pulley systems, chemical systems, magnetic systems, and electric circuits to observe and interpret evidence of interaction.

Level 3 *Subsystems and Variables*

Concepts and processes emphasized in this unit: subsystem, solution, evaporation, histogram, and variable.

The subsystem concept is introduced to give the children a grouping of objects intermediate between a single object and an entire system. The children's work with solid and liquid materials extends their understanding of the subsystem concept. They learn that filtering will separate an undissolved solid from a liquid, but that solids dissolved in solutions must be identified by the residue that remains after the liquid evaporates. Histograms are used to record and interpret data collected by the students. The variable concept helps them to identify and investigate factors influencing their experiments.

Level 4 *Relative Position and Motion*

Concepts and processes emphasized in this unit: reference object, relative position, relative motion, polar coordinates, rectangular coordinates.

The ideas and techniques developed in this unit are related to concepts of earth and space science. Students find that descriptions of position and motion are meaningful only if reference to objects and coordinate systems—both polar and rectangular—are included in the descriptions. An artificial observer, Mr. O, serves the children as an introductory reference object. They see that reference to different objects and coordinate systems leads to different descriptions of position and motion. Children also learn to use a variety of reference frames to describe both the position and the motion of objects in their everyday environment.

Level 5 *Energy Sources*

Concepts and processes emphasized in this unit: energy source, energy receiver, energy transfer, energy chain.

The concepts of energy source, energy transfer, and energy receiver constitute the core of the unit and are illustrated with experiments exploring mechanical and thermal systems. The importance of solar energy to meet some of our needs is emphasized in this unit. The children's descriptions of the amounts of energy transferred from a source to a receiver help to prepare them for understanding and applying the principle of conservation of energy.

Level 6 *Scientific Theories*

Concepts and processes emphasized in this unit: scientific theory, color, magnetic field, electricity, light ray.

The extended investigations and formulation of scientific theories in this unit conclude the physical/earth science sequence. In *Scientific Theories,* children create their own theories to explain their observations of colored light, magnetic interactions, electric circuits, and simple ray optics. Investigations provide opportunities for students to think of theories to explain the operation of systems of interacting objects and to devise tests to distinguish among alternate proposals. In doing so, they gain a deeper understanding of how scientists work.

Life/Earth Science Sequence

Level 1 *Organisms*

Concepts and processes emphasized in this unit: organism, birth, death, habitat, food chain, decay.

The stage is set for the unit as children plant seeds, watch the growth of the seedlings, and experiment to see how external conditions affect growth. Their observations are extended to a model ecosystem—an aquarium. They observe changes that occur in the aquarium, including the growth of plants and animals, animals feeding on plants, animals eating other animals, birth, death, and decay. Experiences with classroom plants and aquariums give children a general introduction to the overall theme of the life/earth science units: the interaction of organisms with their environments.

Level 2 *Life Cycles*

Concepts and processes emphasized in this unit: growth, development, life cycle, genetic identity, plant and animal, metamorphosis.

Attention is shifted from the ecosystem as a whole to some of its important parts—individual plants and animals. Through experiences with living, dead, and nonliving objects, the children have an opportunity to learn these classifications of objects around them. Living and dead organisms are further subdivided into plants and animals. By observing live, growing, developing, reproducing plants and animals, the children become aware of the fact that living objects have life cycles.

Level 3 *Populations*

Concepts and processes emphasized in this unit: population, plant-eater, food web, biotic potential, animal-eater, plant-animal-eater, predator-prey.

The children learn that the individual plants and animals they observed in previous units live as groups in nature. They build, maintain, and observe terrariums and aquariums, and they investigate the interactions of populations—food webs, for example—in each system. The concept of biotic potential can be inferred after the pupils are asked to imagine, with the help of prepared charts, what could happen in a population if reproduction continued without any deaths.

Level 4 *Environments*

Concepts and processes emphasized in this unit: environment, environmental factors, biotic, abiotic, range, optimum.

The environment of an organism consists of biotic factors, which include all the other plants and animals living in the same area; it also includes abiotic factors, such as light, temperature, air, water, and soil. The children experiment with both plants and animals to discover the effects of changing various factors, to establish a range of conditions for testing each factor, and to find the optimum part of a range for each organism. On the basis of data collected from these experiments, students build terrariums with suitable environments for the organisms. They discuss and plan a human environment that includes other organisms on which humans depend.

Level 5 *Communities*

Concepts and processes emphasized in this unit: pyramid of numbers, raw materials, reproduction, community, producers, consumers, decomposers, photosynthesis, food transfer, competitors.

In *Communities,* emphasis is placed upon interactions among different populations of organisms, the most important of which concerns food. Students examine the interdependent relationships among plants (as producers), animals (as consumers), and microorganisms (as decomposers). The children investigate the capacity of green plants to produce food. They build terrariums containing plants, crickets, and salamanders, and observe the food-chain relationships. And they observe the results of decomposition after burying dead crickets in moist sand.

Level 6 *Ecosystems*

Concepts and processes emphasized in this unit: ecosystem, water cycle, oxygen-carbon dioxide cycle, pollution, food-mineral cycle.

The cycle concept is introduced by means of experiments with evaporation and condensation of water that lead to an understanding of the water cycle. Students learn that the ecosystem is maintained by the intake of energy from the sun and by the continuous recycling of materials between organisms and the environment that surrounds them. Ecosystems are seen to include all the concepts in the life/earth science sequence as children see the pattern of ecosystems in North America and identify their own ecosystem. Changes in the balance in natural ecosystems, including those caused by pollution, are studied.

Helping Children Learn with SCIIS

SCIIS is a science program based on direct experience. It is intended to affect the ways children think and reason. In addition it is expected to influence how they will reason and make decisions about problems when they become teenagers and adults. Such thinking and decision-making may well determine the individual's responses to a wide variety of personal and societal issues: Should I smoke or not? Should I vote for or against the use of coal as an energy source in my community? In both cases the intelligent person must be able to understand the variables, critically assess advertising campaigns and the statements of special interest groups, and separate emotional appeals from real evidence.

SCIIS fosters this kind of thinking and decision-making, which is quite different from the kind of skill-oriented learning that takes up a large part of the child's elementary school experience.

The need for skill learning. Children need to learn the skill aspects of language, writing, and arithmetic. Your role in teaching these skills is that of an instructor (one who imparts information) who knows precisely what is to be learned and "gets it across" effectively. The importance of such instruction cannot be questioned, because the skills are basic to participation in society.

Development of reasoning. The individual, however, deserves and needs a great deal more than skill learning to participate meaningfully in a democratic society. The ability to use one's own experiences as a foundation for understanding, interpretation, and decision-making in life is essential. It is this ability to observe, collect evidence, analyze, and use the information obtained from one's experiences that is emphasized in the SCIIS program.

For these reasons your role when teaching such experience-based science is that of a helper and fellow-investigator, rather than only that of an authority or imparter of knowledge. The sections that follow describe the components and organization of SCIIS, and how you can use the program to help children learn both science and the approach to decision-making inherent in science.

PROGRAM COMPONENTS

Teacher's Guide. Central to each unit of the SCIIS program is the Teacher's Guide. It shows how the unit is broken into parts and chapters. Specific learning objectives are listed at the beginning of each Part. The rationale underlying the Part is explained under the heading "Background Information." Next is an "Overview" of the chapters that make up the Part. Any suggestions for organizing time and equipment are provided in notes titled "Planning Ahead" and "Getting Ready."

Each chapter begins with a color panel containing a chapter synopsis, the time suggested for covering the chapter, and a list of materials needed for the activities. Major headings within a chapter are "Advance Preparation," "Teaching Suggestions," "Optional Activities," and "Extending Your Experience (EYE) cards." If background information specific to the chapter is needed, it is included just before "Advance Preparation."

At the end of each Part, notices tell you which EYE cards (in the kit) may now be made available to the children and refer you to the appropriate evaluation activity at the back of the Guide.

Following the last chapter of the Guide you will find an "Evaluation" section, a glossary of important terms, and a page explaining design and use of the equipment and materials kit. The life/earth science units also contain an appendix on care of organisms (following the glossary) and an overall schedule of activities.

Scheduling. One activity may extend beyond a single science session, or several activities may be included in one session. The "Suggested time" for working through a chapter is *only* a suggestion; adapt your schedule to allow for special student interest or for greater use of a chapter or activity that is particularly appropriate in your locale.

Teaching suggestions. Under this heading you will find all the activities intended for use by the whole class. Most activities are carried out by individuals or teams working with the necessary materials to collect data or other evidence. While this happens, you are free to move around the classroom to help those who have problems.

Once the data are collected, conduct a discussion of the results, and encourage children to draw conclusions about the data. The work with the equipment and materials and the subsequent discussions are fundamental to the reasoning and decision-making processes SCIIS is designed to foster.

A willingness to improvise and depart from the teaching suggestions will better enable you to meet your pupils' needs. Students may ask questions not anticipated in the Guide or that do not lead in the direction you planned. When this happens, permit the pleasure of a "side trip" by encouraging interested individuals or small groups to investigate independently and report back to the class.

Optional activities. In many chapters individual and small-group needs and interests are met by the "Optional Activities" section. These expand upon topics brought up in the chapter or help in reviewing concepts studied earlier. You may use optional activities to:

- extend the main activities if a child raises a related question
- emphasize one topic for the entire class
- expand the unit extensively if your class is more mature than usual for this level

Optional activities make use of materials provided in the program, common household supplies, or other readily available items. We hope you will include at least a few of these activities in your program, but we do not expect you to use all of them.

Evaluation and feedback. Feedback is information that comes to a person in response to something the person did. As a teacher, you are collecting feedback from your pupils most of the time. An answer to a question yields feedback. So does a child who looks out the window during your demonstration. Informal feedback is an important way to evaluate the progress of your class. In this Guide, we will try to alert you to feedback situations in which children's responses are likely to influence your teaching plans.

In addition to the feedback suggestions included in each chapter, we have prepared an evaluation section that uses a more formal approach to evaluating your students' learning. In general, there is one evaluation activity for each Part of the unit.

Teacher's glossary. Scientific terms and concepts used in the unit are defined in the glossary. The definitions are appropriate for reference during discussions or review and are not intended to be technically exhaustive. We do *not* recommend that you use the glossary to have children memorize formal definitions of terms and concepts.

Equipment and materials kit. Each SCIIS kit includes all necessary materials for the unit except live organisms, common items such as pencils and paper, and perishable items such as batteries.

Each chapter in the Teacher's Guide begins with a list of materials needed and their location in the kit. Starred (*) items in the list are to be provided by the teacher. "Design and Use of the Kit" (page 116) and labels on each kit drawer also indicate placement of items.

Live organisms. The life/earth science units require that you order shipments of live organisms (already paid for), prepare suitable habitats, and allow time for growth and development of the organisms. The life/earth science kits contain the forms for ordering SCIIS organisms. At the back of the Guide, the "SCIIS Plants and Animals" appendix and the "Schedule of Activities" will help you plan and carry out all work with live organisms.

Student manual. The student manual has two major functions: It helps guide the children through their experiences with the equipment and materials, and it provides a place for the individual to record observations, findings, or measurements. During many activities the children record information about experiments in their manuals. This may provide the basis for later discussions.

Encourage children to make entries independently, even though their reports may disagree with those of classmates or with what you consider to be "correct." Some children may change their responses; let them cross out the first entry and add the new one. In this way, their original record is preserved and may be compared with later observations. Records in the manual should be informative, but they need not be perfect.

In addition to organizing the children's work and record-keeping, the manual contains some problems to be solved either individually or in class discussion. But most of the manual is directly related to the children's experiences with the equipment and materials. This relationship makes the SCIIS student manual different from the typical elementary "workbook."

Collect the manuals periodically to review the children's record-keeping and problem-solving abilities. We suggest you refrain from writing in the manuals, either to commend or to correct mistakes. If you find repeated errors in reasoning or data interpretation, arrange for a conference with the child.

Extending Your Experience cards. These cards (two duplicate sets with a display box) are provided primarily to encourage development of individual interests. We have controlled vocabulary on the cards, so that most children should be able to read them unassisted. The illustrations are intended to help the children work independently. Make each card available — by adding it to those in the display box — at the time its use is recommended in the Guide.

The cards may be used in a variety of ways, ranging from totally independent work to a more controlled situation in which you or an aide suggest and supervise a pupil's use of a card.

Some cards may be used for review or remedial purposes. Some may be assigned to provide additional experiences for children new to the SCIIS program. The cards to be used with review chapters at the beginning of the Guide will prove useful for these purposes.

Encourage children to report orally, in writing, or through picture displays after they complete work with a card. They can report to you, to their team, or to the class as a whole. In this way, children can benefit from the opportunities for language development inherent in the use of the cards.

As children express interest in topics not covered by the cards provided, you might help them develop new cards that relate to their specific interests.

THE LEARNER IN SCIIS

The SCIIS program is intended for children between the ages of 5 and 12–13 years. Therefore, the teaching approach needs to be matched to the learning styles, interests, and capabilities of children of these ages. Research on the learning of young children has led us to recognize a three-stage development in the way children learn. These stages are explained more fully in the following sections.

Exploration. Children learn about something through their own spontaneous handling and experimenting with objects to see what happens. Thus in SCIIS children first explore materials with minimal guidance in the form of instruction or specific questions. The materials have been carefully chosen to provide a background for certain questions the children have not asked before.

You can help exploratory activity by asking questions and making comments that encourage further involvement. An individual's creative use of materials can be pointed out as a means of providing others with new ideas. During exploration activities you have the opportunity to observe the children and draw conclusions about their existing ideas and understandings. This evaluation can be the basis for further planning and instruction.

Invention. Spontaneous learning is limited by preconceptions. After exploration, a child needs new concepts to interpret observations. Since few children can phrase new concepts by themselves, you will have to provide definitions and terms as new concepts arise. This constitutes the "invention."

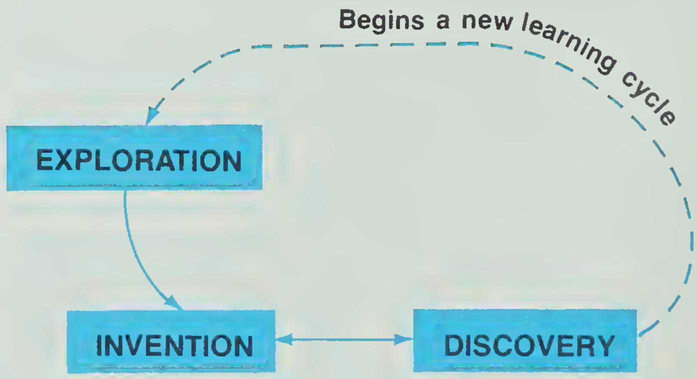
During an invention lesson, be clear and explicit when you give a definition, repeating it several times if necessary. To give the children opportunities to use a concept, encourage them to look for examples that illustrate the new idea. When they report such examples — immediately or during later discovery activities — you gain feedback about their understanding of the concept.

Keep in mind that the "invention" or introduction of a new concept is just the start of an experiential process for a child. Knowledge, understanding, and eventual ability to use the concept in daily life will come from experiences the child has during and after the discovery activities.

Discovery. We use "discovery" to describe those activities in which a child finds a new application of a concept through experience. You may plan a variety of situations leading to discovery, or you may depend on a child's own experiences to furnish these applications. Discovery activities strengthen the original concept and enlarge its meaning. Mastery and retention of concepts are aided by practice and repeated application in the variety of situations provided in the activities.

During discovery sessions, your role is to assist the children so they can effectively work with materials and see how concepts apply. In this stage they are actively involved, and you can spend your time with individuals or small groups to observe their work and to ask questions that spur further investigation. Where necessary, reintroduce the concept previously explained or review earlier ones.

The learning cycle. Exploration/invention/discovery are stages in a learning *cycle* because each stage can always lead to another. Exploratory sessions frequently include discovery activities for prior concepts while creating a need for your introduction of the new concept. Invention sessions frequently lead to questions best answered by giving children opportunities to work on their own, and thus to discover applications of the new concept. Discovery activities can provide opportunities to reintroduce concepts "invented" earlier and they can permit children to explore the next concept. Diagrammatically we can represent the learning cycle this way—



The Learning Cycle

At the beginning of the "Teaching Suggestions" for each chapter we have indicated the stage(s) of the learning cycle emphasized in the activities that follow.

Implementing learning stages. Exploration, invention, and discovery can be implemented with varying degrees of direction. A more structured approach is illustrated when an entire session is used for introduction of a concept in a presentation to the whole class. This should be preceded by exploratory activities and followed by discovery activities of a more personalized nature.

Using a less formal technique, you may introduce a new concept to individual children during their exploratory or discovery activities. To do so, join one child or a small group and use the child's own equipment to illustrate the concept. This method may be used effectively during the review chapters at the beginning of each unit after Level 1. Regardless of the approach you choose, you may have to explain and illustrate a new concept repeatedly to individual children during discovery activities.

TEACHING APPROACHES AND STRATEGIES

Organizing the classroom. Teachers who have contributed to the development of the SCIIS program have found that many responsibilities for preparation and cleanup can be shared by pupils. The following suggestions will help your class enjoy successful laboratory sessions:

1. In many SCIIS activities, children work in small teams — usually pairs. Plan teams carefully, to insure maximum cooperation.
2. For ease in managing supplies and cleanup, assign two or three teams to a work area — a table, or several desks of equal height pushed together. Such a group can share one water container, one waste pail, soil, and other shareable items. They also can exchange ideas about the activity. One member of each group may serve as a laboratory aide.
3. Ask your aides to assemble supplies for each team or group and to help you in passing out equipment. Or you can have them assist you in placing sets of equipment at distribution stations around the room. You may want to post signs at stations to identify equipment and indicate how much is to be used by each team.
4. Invite parents or other community members to assist you as aides in the class. Invite individuals with scientific backgrounds or interests to present special activities relating to activities under way, or to supervise a team working on a special project.

Discussions. Conversation among children or between teacher and children is an important part of the learning process. While participating in experiments, children spontaneously exchange observations and ideas with one another. During an invention session, you illustrate and explain a new concept. When gathering feedback, you may address a question to a particular child.

On other occasions, we suggest discussions in which the children report on their experimental results, compare observations, and sometimes challenge one another's findings. Many children should participate in these discussions, and you, the teacher, should avoid controlling the topic or the pace. Encourage the children to comment to one another, without calling on specific individuals to recite in turn. Grouping them to face one another around an open area promotes exchanges.

If you call attention to disagreement between two findings, you invite evaluative comments and suggestions — which may lead to further meaningful discovery activities. Announcing that one child is right and another one wrong rarely leads to further discovery experiences. Instead, such action encourages children to ask you, as the authority figure, for the answers; it reduces their commitment to independent investigation — which is fundamental to an understanding of science.

Asking questions. The questions you ask and the way in which you ask them will affect the children's work and attitudes. Note the difference between "What did we study yesterday?" and "What did you find out yesterday?" Though both questions call for review of a previous activity, the former only seeks an answer already in the teacher's mind. The latter inquires into a child's own experience.

A question that aims for a predetermined answer is often called *convergent* because of its specific goal. Most questions in multiple-choice tests are of this nature (as are many questions asked by some teachers). A question that allows a variety of answers is often called *divergent* because it may lead in many directions. Provocative discussion questions are usually of this nature.

Suit your questions to your purpose. If you wish to gather feedback about understanding or recall of a certain fact, ask a convergent question. Often this is best done individually, perhaps while small-group work is in progress. When you are looking for a specific answer, make this clear to the child.

If you wish to spark discussion ask a divergent question, and then sit back while several children propose answers. If the children continue their discussion without your leadership, so much the better.

Language development. During extensive use in urban, rural, and suburban schools, the earlier SCIS program proved to be particularly helpful in improving children's oral language skills. Experience with the program was especially effective in the case of disadvantaged children, whose desire to participate in class discussions increased greatly.

In SCIIS we have increased the suggestions and activities especially designed to encourage oral and written language development. The addition of Extending Your Experience cards, for example, encourages language development, since the child is asked to describe orally, write about, or prepare a display about the results of the activity.

Mathematics development. The SCIIS program can also do much to encourage children's development of mathematical concepts and processes. Children are urged at all levels to consider the quantitative aspects of their observations and activities. For example, in the *Material Objects* unit (Level 1) the child's concept of number is reinforced by having the child select a specific number of objects as indicated by a numeral card you display. Later, in *Subsystems and Variables* (Level 3) and *Environments* (Level 4) the use of quantitative measurements to produce histograms and graphs is emphasized. Such use of quantitative data provides opportunities for reviewing mathematical concepts, processes, and skills. For many children the introduction to histograms and graphing will be their first experience with these powerful mathematical tools.

Children new to the program. The great appeal of SCIIS derives from its reliance on direct experience, and most children will learn quickly how to participate effectively. However, a few may have difficulty because they lack background or are not accustomed to working independently. You can take several steps to make the transition easier for them.

First, all units after Level 1 begin with a review. By supplementing the review with appropriate activities and EYE cards from previous units, you can help children become familiar with concepts introduced earlier in the program. Use these activities individually or with groups.

Second, you can help a child gain confidence in independent work by showing him or her that there are often a number of alternate acceptable procedures and results in an activity. Encourage the children to find various ways to use pieces of equipment, commend their ideas, and let them share their findings with others.

Life Cycles: An Overview

The investigations of living things begun in *Organisms* are further developed in *Life Cycles*. The *Organisms* unit introduced the children to a broad picture of interacting animals and plants. *Life Cycles* focuses their attention on the lives of individual, representative plants and animals and their patterns of development and growth.

The children see growth, along with other attributes, as characterizing living things. Through experiences with living, dead, and nonliving objects, the children have an opportunity to learn these classifications of objects around them. Living and dead organisms are further subdivided into plants and animals.

The children first observe development and growth in plants. They have ample opportunities to learn the difference between these two important biological concepts as they plant seeds that develop into seedlings, then grow larger.

The children also see how seeds and eggs appear much alike but become vastly different as they mature. Frogs, fruit flies, moths, crickets, butterflies, and mealworms develop and grow under the children's care. Metamorphosis is observed as the children see some of the animals develop from the egg to larva to pupa and adult stages. In addition to seeing the development and maturation of animals, children also see adult animals die and new ones born.

Concepts. The following fundamental biological concepts emerge from the activities in this unit:

growth
development
life cycle
genetic identity
plant and animal
metamorphosis

Other terms introduced, though receiving less emphasis, contribute to the children's understanding. They are: living, dead, nonliving, egg, larva, pupa, adult, experiment, fruit, molting, and seed.

Part One

Living Things

OBJECTIVES

To identify organisms.

To describe habitats.

To illustrate a food chain.

To list the characteristics of living, dead, and nonliving objects.

To sort organisms into plants and animals.

BACKGROUND INFORMATION

In the previous SCIIS life science unit, *Organisms,* the children had an opportunity to have experiences leading to the concepts *organisms, habitats,* and *food chains,* among others. These concepts are reviewed here as preparation for the *Life Cycles* concepts.

An organism is any living thing—plant or animal. And the place where a particular organism lives is its habitat, or home. While a sparrow might live anywhere, even in a faraway land, the sparrow living in the eaves of your home has its habitat there.

The word *environment* is often used interchangeably with the term *habitat*, but it does not have the same meaning. This environment, which is appropriate for sparrows, could be found in many places, but any one sparrow has only one habitat—its home. The general environment of a sparrow, unlike its habitat, could be found in many places.

A *food chain* is a linking of a plant to a plant-eater and (in some cases) to an animal-eater. Food chains are usually symbolized in this fashion:

corn → grasshopper → frog → cat

Such diagrams illustrate the interdependence of the organisms. Nearly all such interdependencies among organisms revolve around the food relationship.

Though the concepts *living, dead,* and *nonliving* need little explanation, they are important categories for children to understand. Some objects are quite obviously alive, especially if they move or grow. The distinction between *dead* and *nonliving* is more difficult: only objects that were once alive can be classified as dead, and only objects that never lived are called nonliving.

Of course, you may think of objects such as a hammer, having a steel (nonliving) head and a wooden (dead) handle, and worry about how to classify the hammer. The solution to such "problem objects" is either to classify the different components individually or to classify the hammer as both dead and nonliving. The important point is that the children learn to distinguish between these three classifications and to use the new language terms to improve both their communication with others and their thinking.

Living and dead organisms may be further sorted into *plants* and *animals*—a useful division for purposes of description and communication. The distinction between plants and animals is easy at the frog and bean level but is nearly obscured at the microscopic level. Some organisms are plantlike in that they photosynthesize their own food but animallike in that they eat other organisms. Biologists are still arguing the exact definitions of plants and animals.

OVERVIEW

In Chapter 1, "Review of *Organisms*," you will review the concepts *organisms, habitat,* and *food chain*. Three new classifications of objects are introduced through activity and discussion in Chapter 2, "Alive, Dead, or Nonliving." Chapter 3, "Plant or Animal," further classifies organisms as the learning cycle continues.

GETTING READY

You will need some living, nonliving, and dead materials for Chapters 2 and 3. Refer to the "Teaching Materials" and "Advance Preparation" sections. Select a spot for a short field trip, also, as described in Chapter 2.

Before doing any work in the classroom with living organisms, be sure to read "SCIIS Plants and Animals," on pages 106–115.

1 Review of Organisms

SYNOPSIS

Children review the concepts **organisms, habitat,** *and* **food chain** *by playing a game and going outdoors.*

Suggested time: *about 1½ sessions*

TEACHING MATERIALS

For each child:

Drawer 1

student manual pages 2–4

For the class:

crayons*
tape*

Drawer 1

Organisms game cards
Organism cards
Habitat cards
Food Chain cards

* provided by the teacher

ADVANCE PREPARATION

Locate an area on or near the school grounds where your pupils can see at least five different kinds of plants and four different kinds of animals. These might include such common organisms as grass, trees, bushes, pigeons, dogs, humans, and ants; the number of each organism they see is less important than that they see several kinds.

Arrange the Organisms game cards so that they spell *organisms* when dealt from top to bottom.

TEACHING SUGGESTIONS

This review of concepts introduced in the *Organisms* unit forms part of the discovery phase for those concepts.

Review of *organisms.* Tell the children they are going to play a word-finding game. They will guess the name of a plant or animal from the way one student acts it out.

Without letting the rest of the class see the card, show one child the lettered side of the *O* card. Ask the child to act out the object pictured on the unlettered side—in this case, an owl. Hooting and other oral clues, not usually allowed in other charade games, are allowed. When a class member guesses the object's name, tape the card letter *O* to the upper, left-hand edge of the chalkboard and complete the word *owl* using chalk.

Proceed through the card deck in this fashion, having a different boy or girl act out each object. Each time a plant or animal is named correctly, tape the lettered card below and to the right of the previous letter and complete the name in chalk. When all the plants and animals have been named, the spelling of *organisms* by the initial letters will be obvious.

When the word is completed, circle it (as in Figure 1-1) and ask if anyone can say it or knows its meaning. If few children seem familiar with the word, give them the clue that each of the acted-out objects is an organism. When they seem to understand that an organism is any plant or animal, ask them to name other organisms they have seen.

Organism hunt. As further reinforcement, take the children outdoors to the area you selected earlier. Tell them to look around for organisms. If they seem to look for animals only, remind them that plants are organisms, too.

Review of *habitat.* After about fifteen minutes, or whenever you think the children have recalled or grasped the organism concept, ask if anyone knows what to call the place where an animal lives. If necessary, tell them the answer—its *habitat.*

Point out one of the animals and ask a child to show

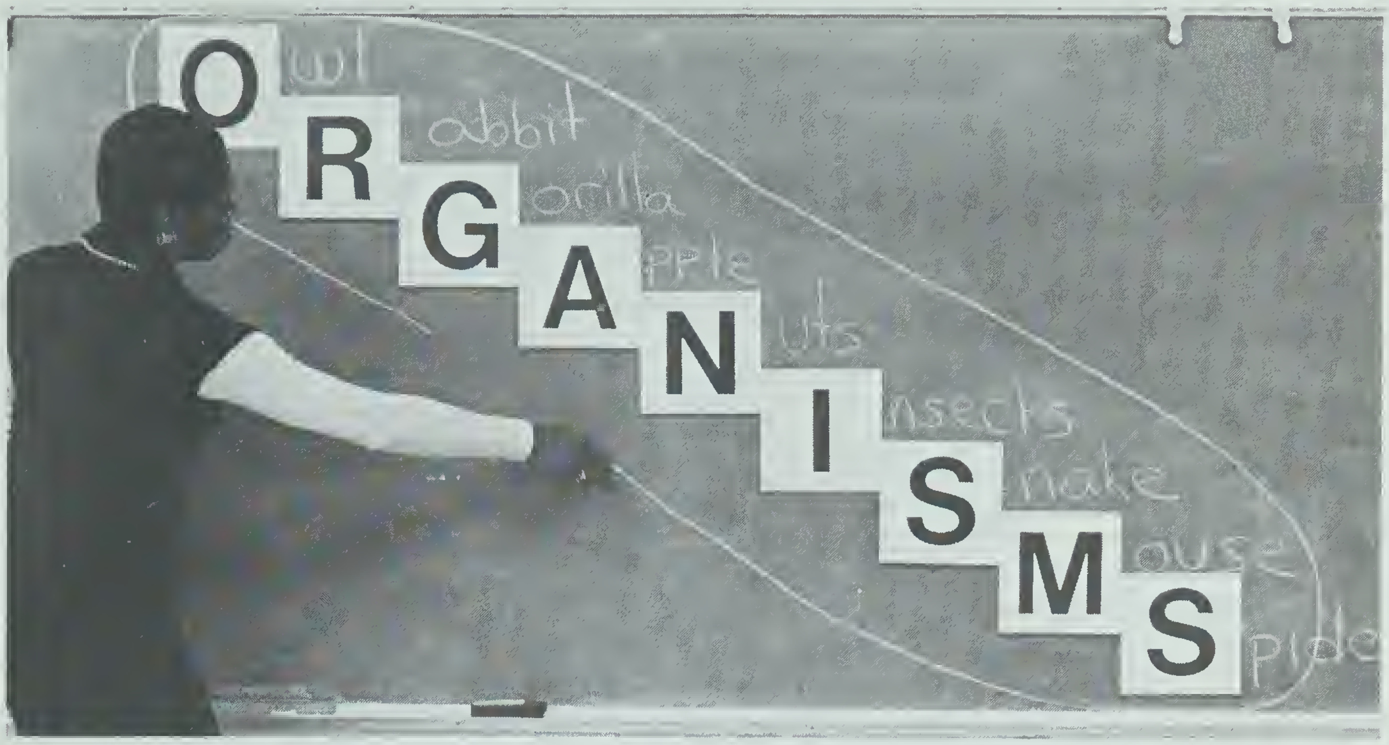


Figure 1-1. Completed list of organisms.

the others what its habitat is. The answer will probably be "Here." Try to get a more specific description of the animal's habitat ("The damp soil under a rock"). Encourage the children to find and tell about other habitats in the area and which animals live in them.

Return to the classroom after the review is finished. Depending on your schedule, you may want to continue this chapter now or resume it on the next science day.

Review of *food chain.* Remind the children of the organisms they saw outdoors and ask if any of those organisms they saw are ever eaten by animals. They may know that grass is eaten by cows, seeds by pigeons, flies by spiders, and so on.

Print the organisms' names on the chalkboard and connect the names with arrows, as shown in Figure 1-2.

Try to draw out suggestions of other food chains, especially those having more than two links. Tell the children that these are examples of *food chains*—food, because at least one organism is food for another (or goes into another), and chain, because the organisms are linked as the parts of a chain are.

Continue making food chains based on the field trip organisms and then ask the children to suggest food chains using other organisms. If they cannot, print *humans* and add an arrow pointing to the word. They should be able to name some plants and animals we use as food (chickens, cows, carrots, apples) as well as some of the plants eaten by the chickens and cows. Whenever they name an animal, encourage them to name also the organisms that animal eats.

Figure 1-2. Two examples of food chains.

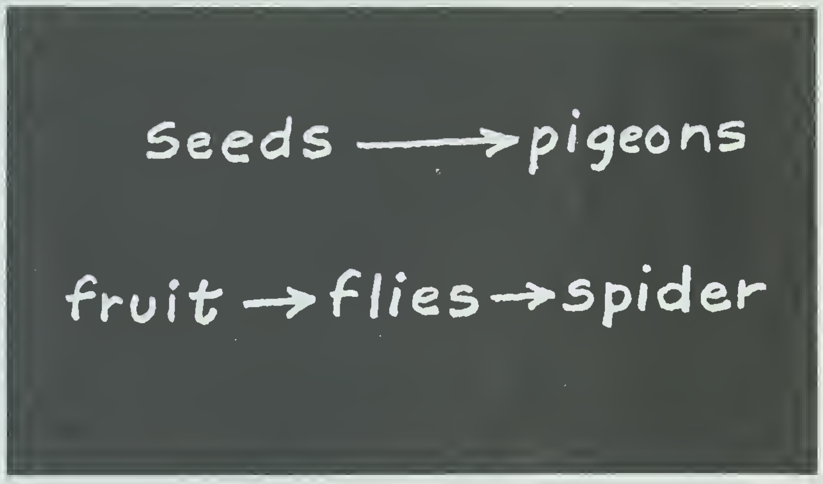
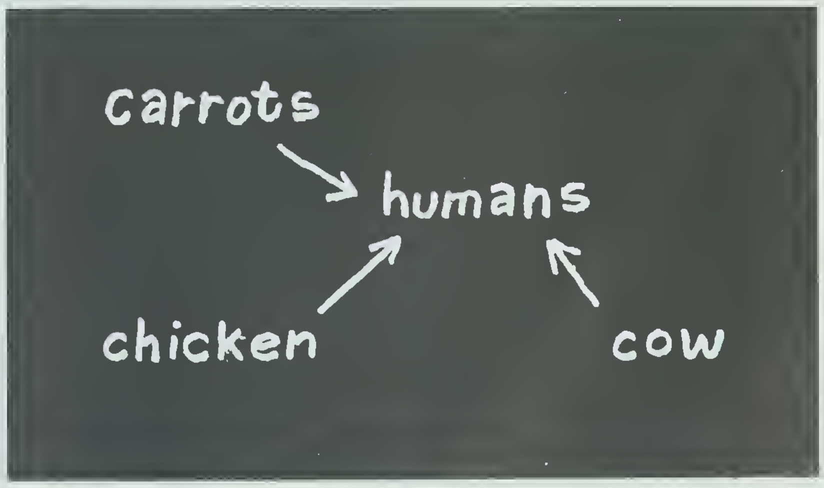


Figure 1-3. Humans in food chains.



Discussion. To bring together the concepts reviewed in this chapter, ask some or all of the children to make up sentences that include one or more of the words *organism, habitat,* or *food chain*. A child might say, "My dog is an organism" or "Squirrels live in nests and that's their habitat" or "Everything eats something and so all plants and animals are part of a food chain."

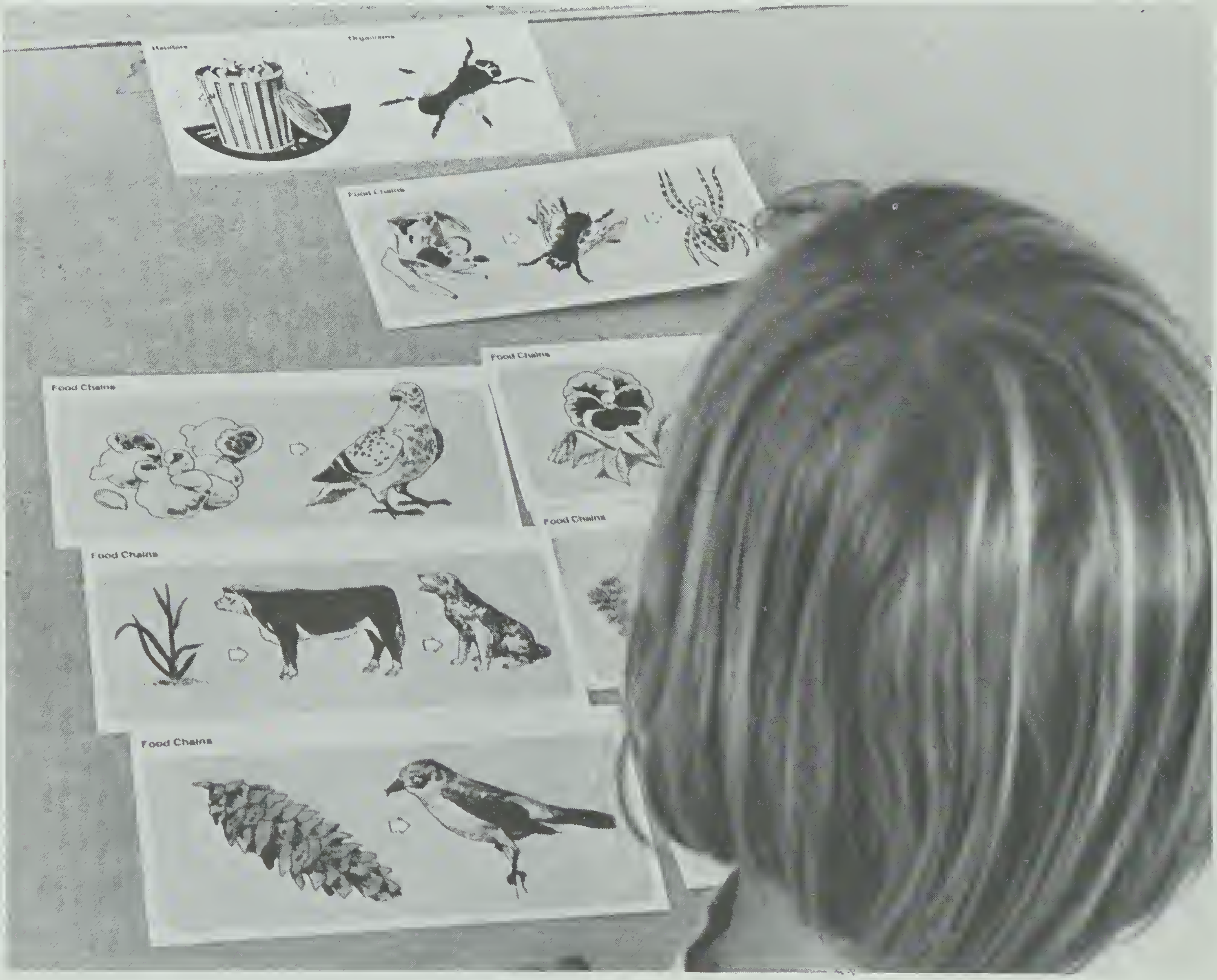
Organism, Habitat, and Food Chain cards. These cards provide further review of the concepts. Divide the class into teams of two and ask one child to give each team an Organism card. Display the Habitat cards on the chalk tray, on a table, or on the floor. Tell the children they should look at all those cards and choose one which could be a habitat for their organism.

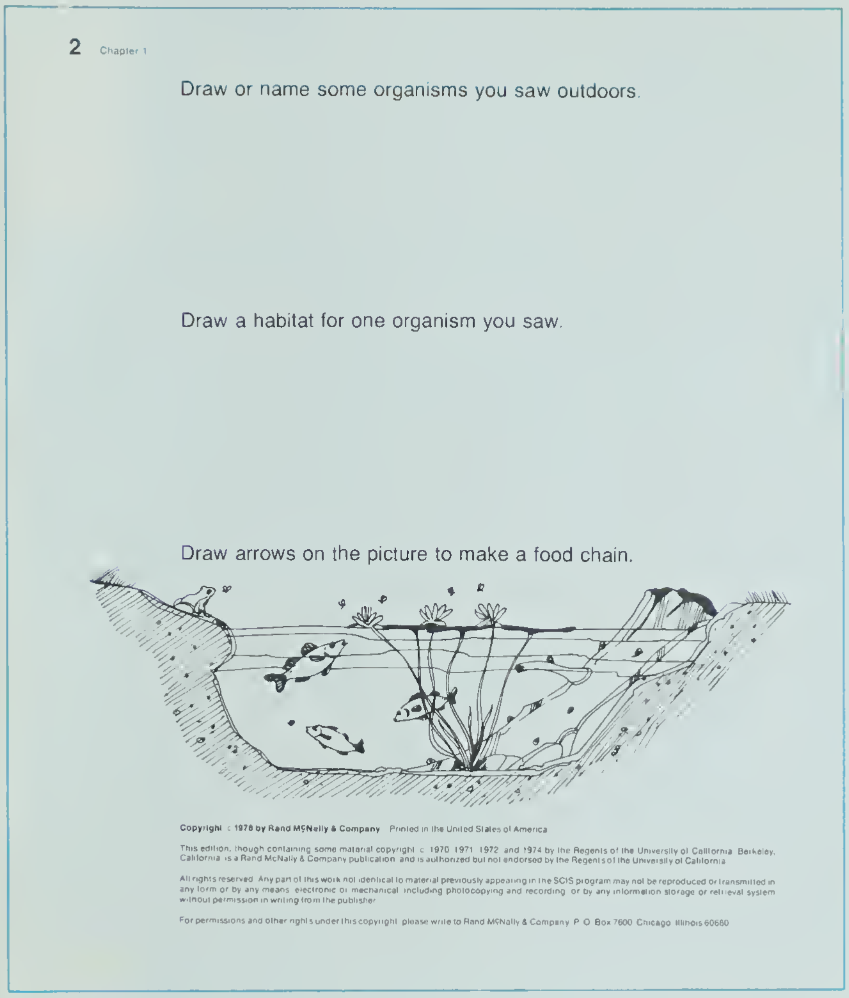
Have each team find the best habitat for its organism. After each organism has been matched with its habitat, display the Food Chain cards. Invite each team of children to choose a Food Chain card that has their organism in it. When the activity is over, each team should have one card of each kind, as shown in Figure 1-4.

Encourage the children to go see what the other teams have arranged. They might see how they could share their Organism, Habitat, and Food Chain cards with other teams. Some choices will be inappropriate, not because the children don't understand the concept but because your area does not have the pictured organisms or because the children haven't seen the organisms. Also certain organisms in your part of the country may be adapted to a habitat or food supply other than that shown by the cards.

When the children are through, have them sort the three kinds of cards before you return them to the kit.

Figure 1-4. Choosing a food chain card to accompany animal and habitat cards.





2 Chapter 1

Draw or name some organisms you saw outdoors.

Draw a habitat for one organism you saw.

Draw arrows on the picture to make a food chain.

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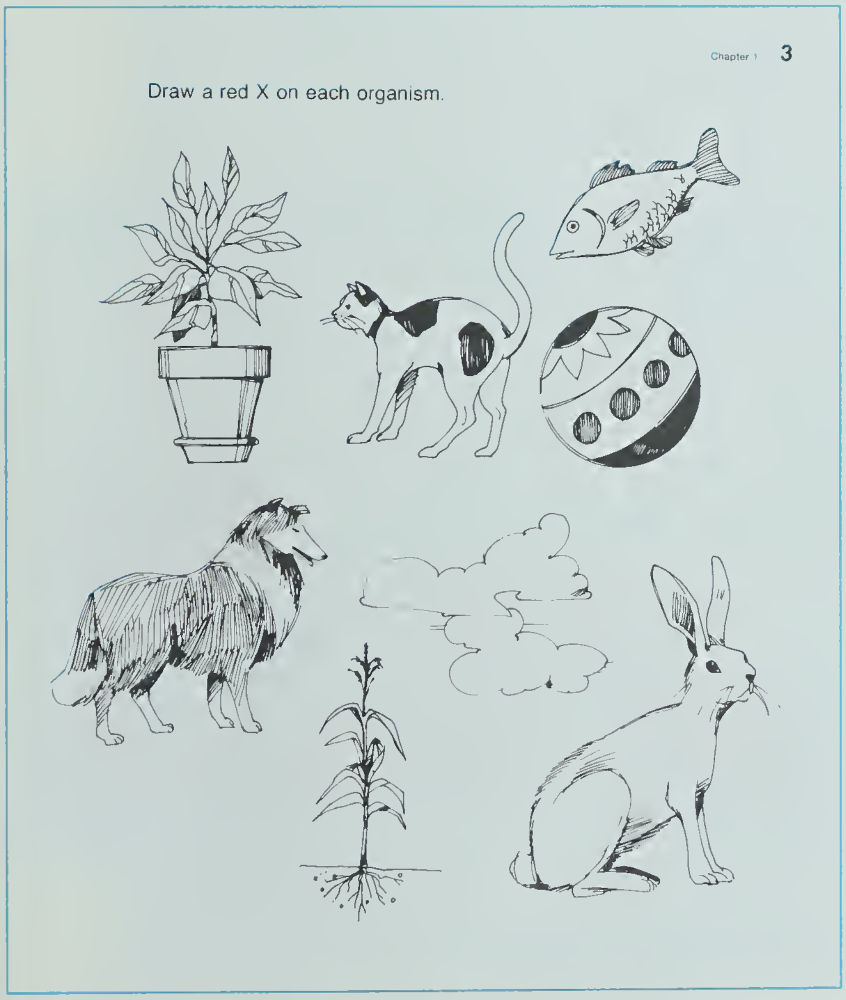
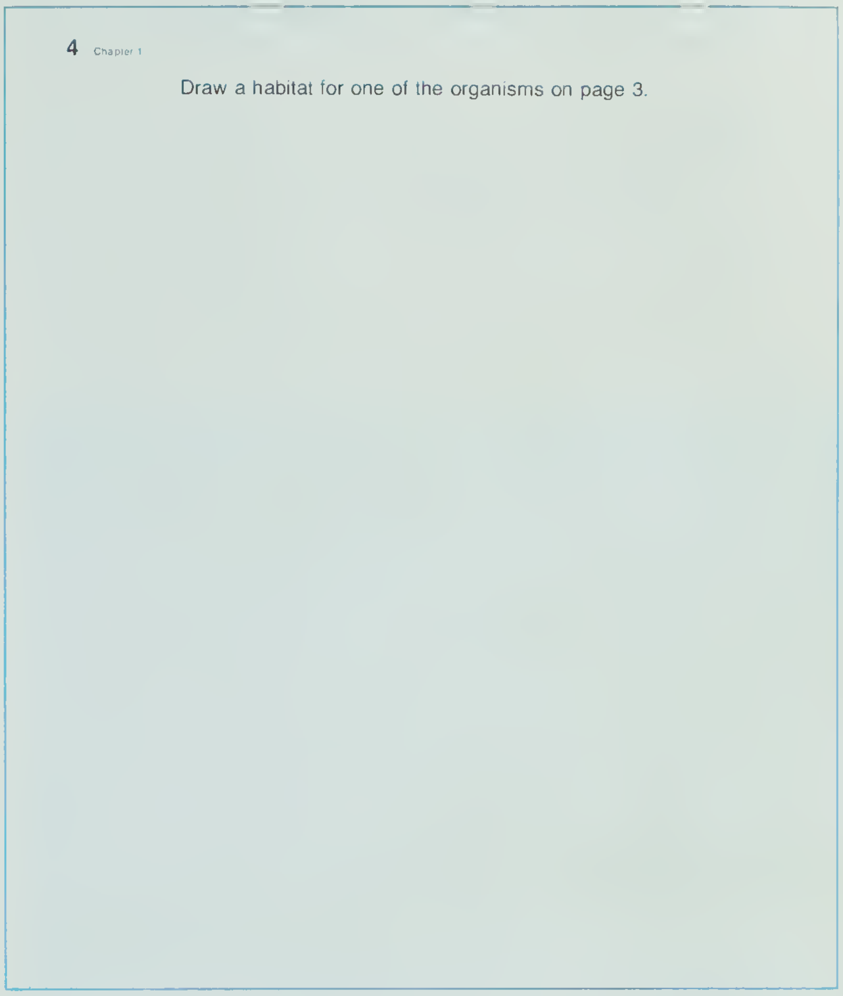


Chapter 1 3

Draw a red X on each organism.



4 Chapter 1

Draw a habitat for one of the organisms on page 3.

Student manual pages 2–4. You may have to remind the children to write their names on the manuals.

Have the children list, or draw and color, a few of the organisms they saw while on the field trip. Also ask them to add arrows to the pond picture on page 2, showing a simple food chain.

On page 3, the children may identify organisms by drawing red X's on them. Page 4 provides space for a drawing of a habitat for one of the organisms.

OPTIONAL ACTIVITY

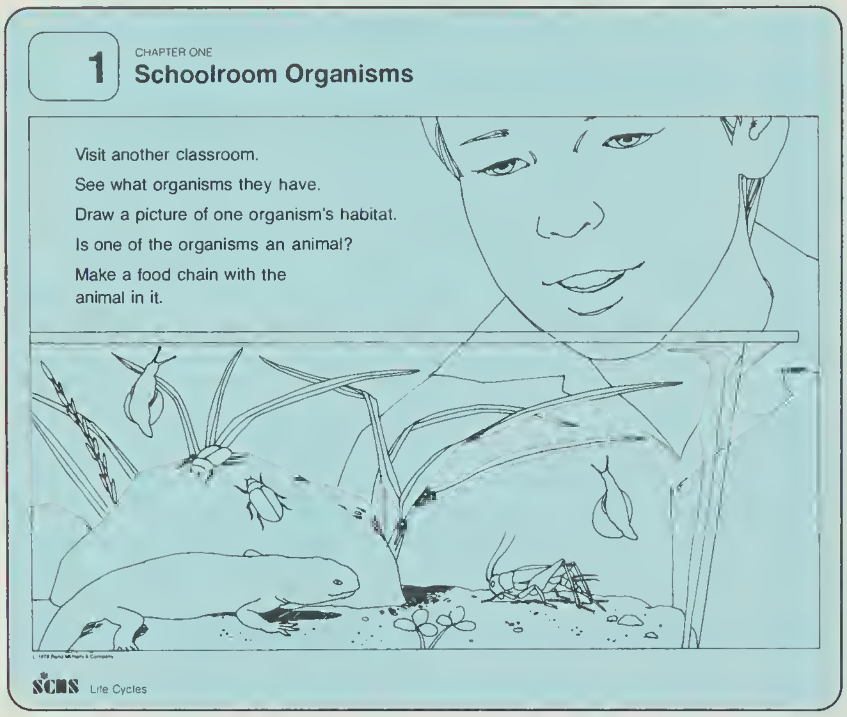
A classroom display. The children can make a long butcher-paper mural representing many or most of the major organisms in your state or region or even those of another country you are currently studying.

Many organisms, habitats, and food chains can be drawn, charted, or made into a montage as a major poster or display for the classroom or hallways. The children will acquire a good review of some major concepts by carrying out this activity.

EXTENDING YOUR EXPERIENCE CARDS

For suggestions on using these cards, see page 93.

1. Schoolroom Organisms. This activity is a reinforcement of the organism and food chain concepts. It may be used by any child. Children who use this card will need paper, crayons, and permission to visit a classroom containing some plants and animals.

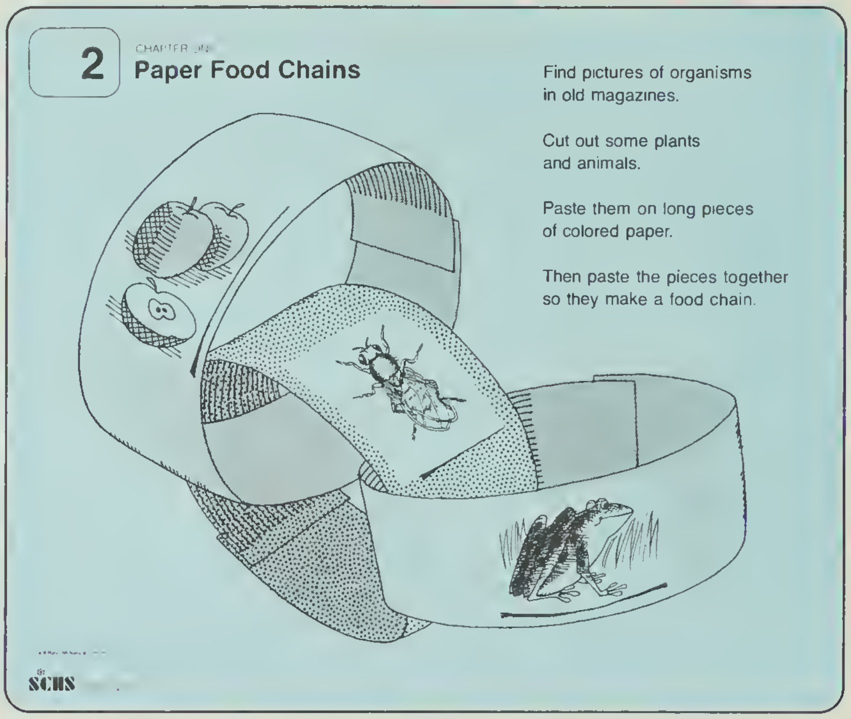


1 CHAPTER ONE
Schoolroom Organisms

Visit another classroom.
See what organisms they have.
Draw a picture of one organism's habitat.
Is one of the organisms an animal?
Make a food chain with the animal in it.

SCIS Life Cycles

2. Paper Food Chains. Provide some old magazines containing photographs or drawings of organisms for the children. They will need construction paper and paste also. When the chain is completed, each link should contain the picture of an organism that is eaten by the animal shown on the next link.



2 CHAPTER ONE
Paper Food Chains

Find pictures of organisms in old magazines.

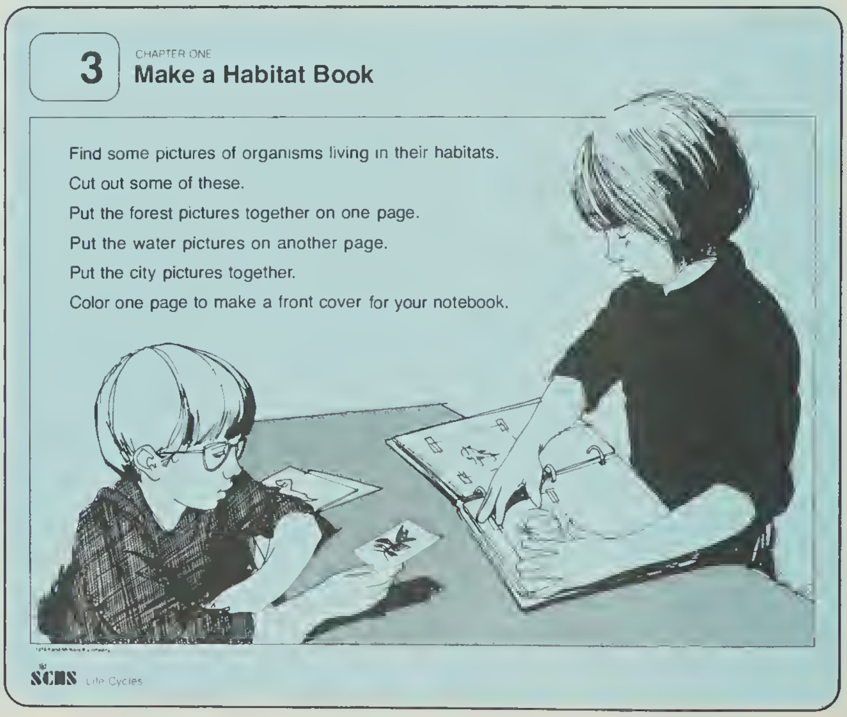
Cut out some plants and animals.

Paste them on long pieces of colored paper.

Then paste the pieces together so they make a food chain.

SCIS

3. Make a Habitat Book. Give the children some more old magazines and some notebook paper and paste. You may have to guide children who are having trouble with the habitat concept.



3 CHAPTER ONE
Make a Habitat Book

Find some pictures of organisms living in their habitats.
Cut out some of these.
Put the forest pictures together on one page.
Put the water pictures on another page.
Put the city pictures together.
Color one page to make a front cover for your notebook.

SCIS Life Cycles

2

Alive, Dead, or Nonliving

SYNOPSIS

Children investigate various objects which are identified as living, dead, *or* nonliving.

Suggested time: *This activity requires one session, followed by short observations over a two-week period.*

TEACHING MATERIALS

For each child:

student manual pages 5 and 6

Drawer 2

1 sprig air fern

For the class:

soil‡
2–4 living plants or plant parts*
2–4 living animals*
2–4 dead plants and animals or parts (such as a chicken bone)*
2–4 nonliving objects*
chart paper*
felt-tip pen*

Drawer 2

16 magnifiers

For the teacher:

glass or metal dish*
matches*

* provided by the teacher
‡ Sand and Soil box

ADVANCE PREPARATION

Collect some nonliving objects. Also arrange to bring in some living objects, including at least two kinds of plants and two kinds of animals (perhaps one a furry type, the other a fish, lizard, worm, or insect).

Hide all objects from the children until you are ready to show them.

Select a field trip site that is likely to have living, nonliving, and dead objects.

TEACHING SUGGESTIONS

After a short period of exploration, you invent the concepts *living, dead,* and *nonliving*.

Examining objects in the classroom. In the classroom, arrange the children so they will be able to see you and help sort all the objects you will show them. You probably will want them to sit in a circle on the floor.

Select a live animal from its hiding place, leaving the other objects hidden. Set the animal in the display and sorting area. After the children have made their exclamations and comments, ask them to name some of the characteristics of this object. You may have to remind them to describe its physical characteristics (size, shape, color, activity, texture, etc.) rather than stating its function ("A worm is for fishing" or "A kitten is for loving").

As the children describe the object, one of them may suggest it is an animal or that it is alive. Encourage a discussion of the word *alive* in order to find out what the children think it means. As they talk, list the characteristics they mention on a piece of chart paper or the chalkboard. When they have expressed most of their ideas, print the word *Living* above their list of characteristics and introduce the term as a word which describes any plant or animal which has these characteristics.

Next show a dead object such as an obviously dried-up plant, a fly or other insect, and have the children describe the object by its characteristics. As before, encourage discussion of the dead object's characteristics. On a new piece of chart paper, list the characteristics of the dead object as described by the children. When they have contributed what you think are enough characteristics, print the word *Dead* as a heading for the list. As soon as you have done that, introduce the term *dead* as a word describing an organism that was living but isn't alive now.

Now select a plastic toy, rock, or metal object and encourage the children to describe it. Encourage and collect comments from the children on the characteristics of this object. If the children suggest this object is dead, correct them by explaining that something can only be dead if it was once living. When you

Figure 2-1. Characterizing living and dead objects.

have completed the new chart list for this nonliving object, print the term *Nonliving* above the list. Explain that the object you have shown them is *nonliving;* that is, not living now and never having lived.

To review and reinforce the concepts *living, dead,* and *nonliving,* use all or some of the objects you have not yet shown.

As you display each object, ask the children to decide whether the object is alive, dead, or nonliving. Not all objects you have collected may be easy to classify or even familiar to the children, so encourage the students to defend why they think an object belongs in one category or another.

Examining objects outdoors. If possible, take the children outdoors to look for objects which are alive, dead, or nonliving. If necessary, this activity can be done in the classroom, but it is not so much fun, because the variety of objects is usually too limited.

Tell the children that when you get outdoors, you will start pointing at objects. Each time you point at something, they should say "living," "dead," or "nonliving."

At first, select objects that you think will be easy for the children to classify. After the children have practiced for about five minutes, point to such objects as seeds (living though nonmoving), clouds (nonliving though moving), rustling or moving fallen leaves (dead though moving). These objects are not what they may seem at first, and the children's comments will probably indicate that (1) their inexperience or lack of knowledge limits their ability to classify in this way and (2) an unexpected or contradictory idea, such as that a seed is living, is more interesting than an expected conclusion.

During this outdoor observation, allow the children as much discussion time as they need. If they fail to classify certain objects, such as water, seeds from the ground, shells, or leaves, bring those objects back to the classroom for testing.

Figure 2-2. Classifying objects as nonliving.

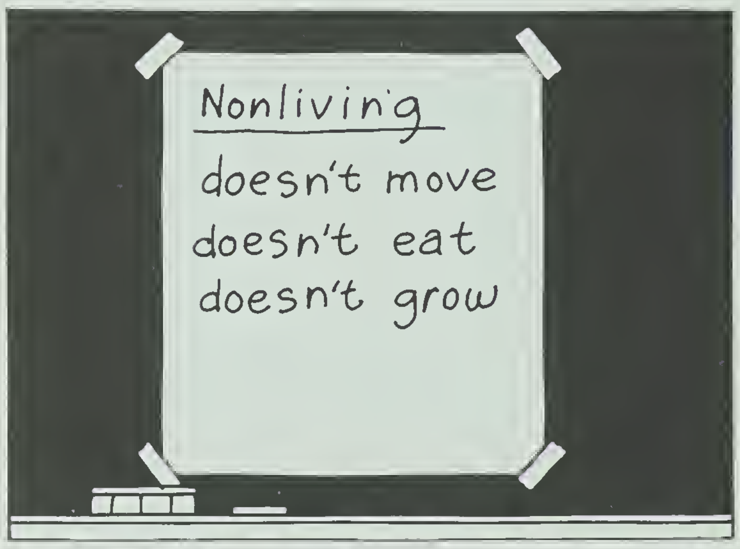


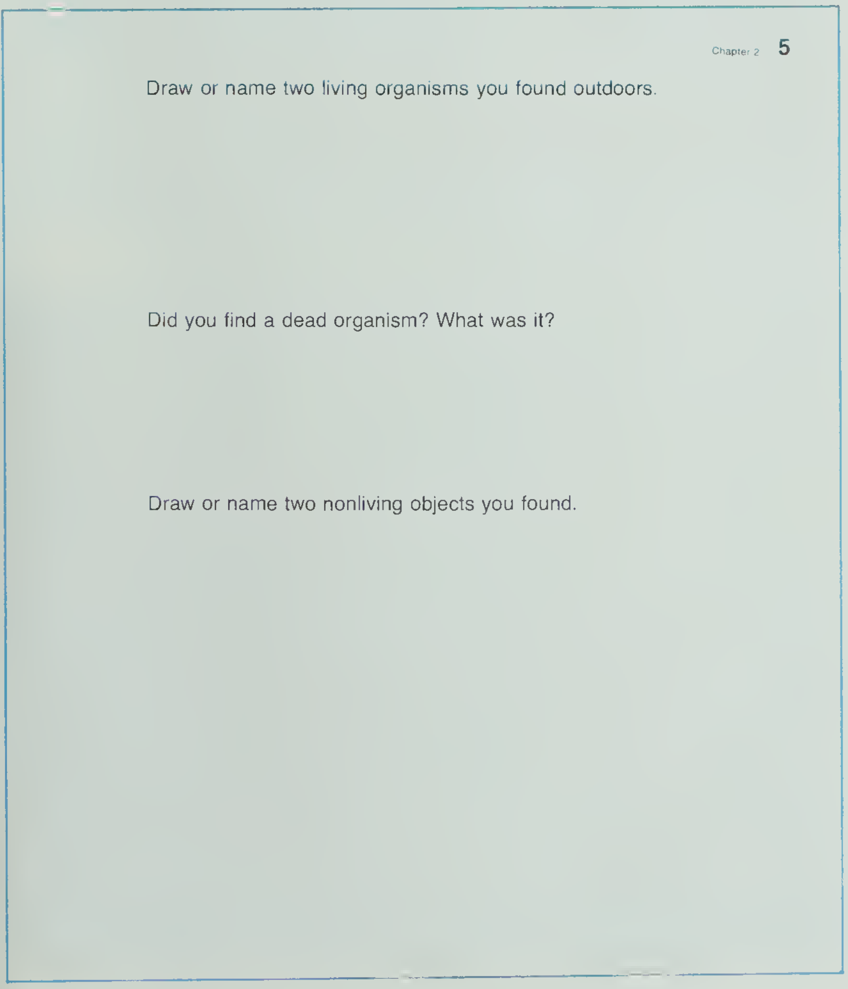
Figure 2-3. Classifying an object outdoors. Nonliving or dead?

Testing objects for life. While it is difficult to test for death or nonlife, the children can test for the characteristics of living things. Have them consult the list of characteristics they made for *Living*. Then encourage them to set up an experiment by asking them how they could find out whether their object is living.

If the children have suggested living things grow, then the object could be planted, fed, or watered and watched for growth. If the children think living objects make sounds, then they could listen to their objects. They may be able to suggest any number of tests to determine if an object is living. By using their senses, comparing the object in question to known living, dead, or nonliving objects, and discussing and testing, the children will gain valuable experience that will improve their skills of observing and reasoning.

Using student manual page 5. After the field trip and the follow-up work, provide some time for the children to list or draw a few examples for each of the three kinds of objects: living, dead, and nonliving. When you examine the completed student manual pages, look for confusion between dead and nonliving objects in the children's suggestions.

Using student manual page 6. This page provides extra practice for the children. It is especially useful if you were not able to take them outdoors.

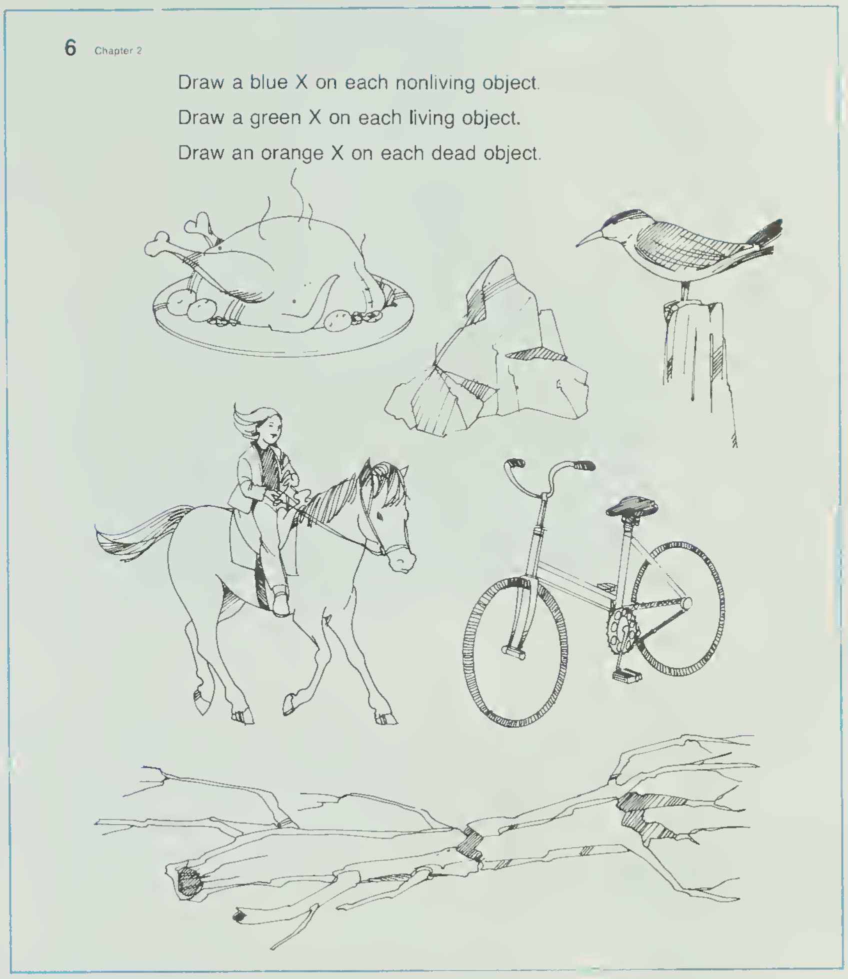


Chapter 2 5

Draw or name two living organisms you found outdoors.

Did you find a dead organism? What was it?

Draw or name two nonliving objects you found.



6 Chapter 2

Draw a blue X on each nonliving object.
Draw a green X on each living object.
Draw an orange X on each dead object.

Testing some "green stuff" for life. Distribute a piece of air fern to each child and ask if students think this object is alive, dead, or nonliving. (Do not tell them it is actually the skeleton of many primitive animals called bryozoans. More information on bryozoans is given on page 13.)

Distribute the magnifiers and give the children some time to observe the air fern. Some children may tell you that their mothers have one at home and it's a plant that doesn't need water or soil. Others will insist that it is plastic.

After children have had ample time to observe the bryozoan skeleton, ask them to tell you if they have decided whether it is alive, dead, or nonliving. Probably they will disagree. Whatever the child thinks, he or she should have some reasons for the decision.

Experiments. After the children have had an opportunity to tell what they have discovered:

- Ask what experiments they could do to find out if this object is alive, dead, or nonliving.
- Encourage them to investigate the object, using magnifiers, water, cups, and so on.
- They may suggest waiting to see if it will grow. Have them follow through, being sure they measure its length now and later.
- They can "plant" it in soil, water, or air and watch to see if it grows.

Figure 2-4. Is it alive, dead, or nonliving?

Demonstration. Some children may want to see if the air fern will burn like wood or melt like plastic. You may conduct a burning test for them by placing a piece of the material in a glass or metal dish and setting fire to it. (It burns like a small, dry weed.)

Results. Allow the children to observe their experiments for a week or so. Then gather the children and have them share and discuss their results. The children should then decide whether the air fern is living, dead, or nonliving. Have them base their decision on the evidence from their experiments by asking:

- Did it grow longer?
- Do you see any roots?
- What makes you think it's alive (or dead or nonliving)?

Planning ahead. Preview the Plant and Animal cards used in the next chapter. You will need two live animals and one dead one (or animal parts such as chicken bone) and two live plants and one dead one for demonstration purposes.

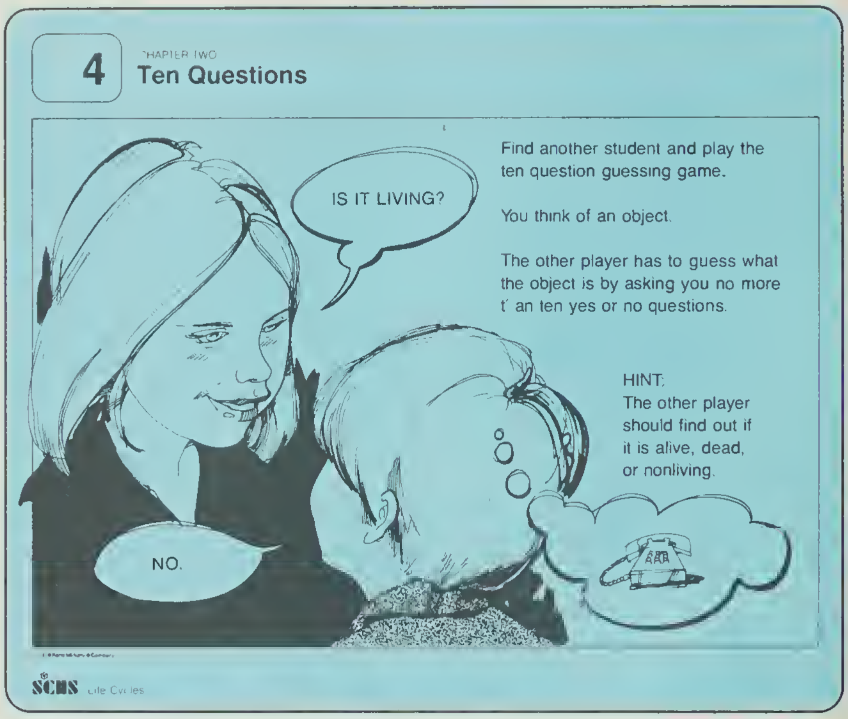
OPTIONAL ACTIVITY

A guessing game. You think of an object and lead a guessing game with the children in which it is to their advantage to use the living, dead, and nonliving, plant, and animal concepts to make the most of their limited number of guesses. The children may ask any question that may be answered yes or no. Divide the class into two or three groups and allow each group, alternately, to ask a set number of questions of you to find out what object you are thinking about. You might begin by allowing about ten questions from each side. You think, for example, of the classroom meterstick or yardstick. Children who first determine if it is alive, dead, or nonliving will have narrowed the range of possible objects considerably.

EXTENDING YOUR EXPERIENCE CARDS

4. Ten Questions. If you have not played the game described in the "Optional Activity," the children may need an explanation from you to expand the short description on the card.

5. N, D or L? Decide how you want the child to attach these tags. Rubber cement is probably the easiest substance to remove from door handles, walls, chalkboard, and all other objects the student may tag.



4

CHAPTER TWO

Ten Questions

Find another student and play the ten question guessing game.

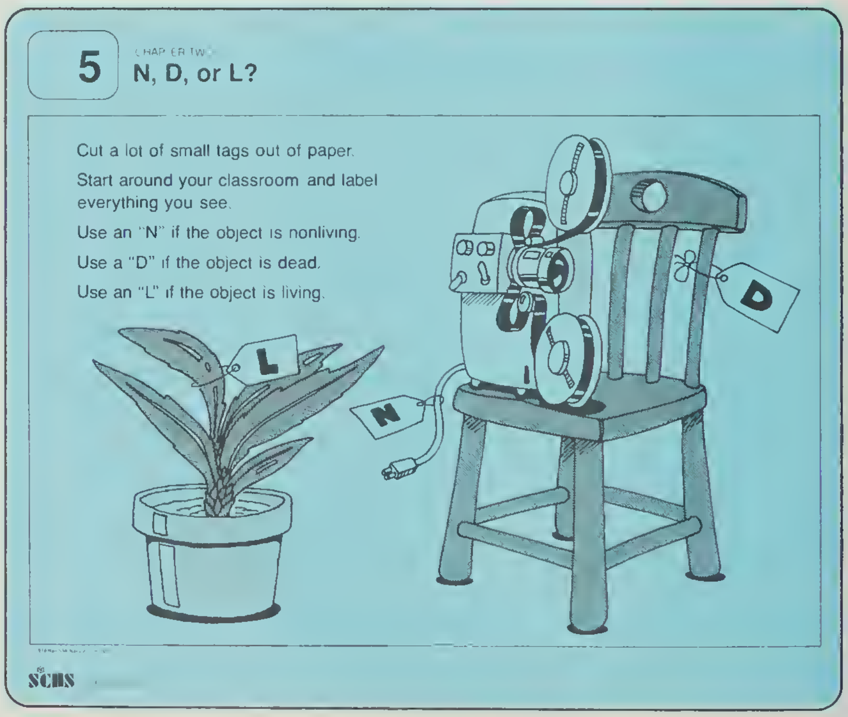
You think of an object.

The other player has to guess what the object is by asking you no more than ten yes or no questions.

HINT:
The other player should find out if it is alive, dead, or nonliving.

IS IT LIVING?
NO.

SCIS Life Cycles



5

CHAPTER TWO

N, D, or L?

Cut a lot of small tags out of paper.

Start around your classroom and label everything you see.

Use an "N" if the object is nonliving.

Use a "D" if the object is dead.

Use an "L" if the object is living.

SCIS

3

Plant or Animal

SYNOPSIS

Children classify living and nonliving objects into plants and animals.

Suggested time: ***one session***

TEACHING MATERIALS

For each child:

student manual pages 8 and 9

For each team of four children:

Drawer 1

1 sort mat
1 set Plant and Animal cards

For the class:

2 live animals*
2 dead animals or parts (such as a fly or a chicken bone)*
2 live plants*
2 dead plants*
glue or paste*
cardboard*

Drawer 1

Central Park gameboard

Drawer 2

1 sprig air fern

* provided by the teacher

TEACHING SUGGESTIONS

This activity overlaps two groups of concepts: the discovery phase of *alive, dead,* and *nonliving* merges into the exploration and invention phases for *plant* and *animal*.

Living, dead, and nonliving objects. Arrange four demonstration objects on a display table: two live plants and two dead plants; or two live animals and two dead animals (or parts of one, such as bones from meat or poultry).

Review the living, dead, and nonliving concepts with the children by asking them to categorize each of the four objects.

Now ask them if they can sort those objects into two groups on your table. You might let one or two children physically move the objects into two different areas of the table.

If they sort according to living and dead, as they probably will do, provide some encouragement and then ask all the students if there is another way to sort the objects. They may sort according to color, size, or any number of other characteristics. One of their sortings will probably be into plant and animal groups.

Sorting in another way. When a child groups plants in one area and animals in another, invite the pupil who suggested this grouping to explain the reason for it. If no one suggests that one set is *plants* and the other *animals*, you should do so. Most children will readily agree with this grouping.

- To find out whether the children understand the obvious differences between plants and animals, ask them for some examples of each.
- Do not expect sophisticated, dictionary definitions; if they define plants as green things having roots and leaves, and animals as moving things having skin, their understanding is enough at this time. Many children who quickly recognize turtles, monkeys, and worms as animals will not realize that humans also are animals.

A mystery organism. Now show the children the bryozoan skeleton, or air fern, that they observed in Chapter 2. Tell them it is not a plant but an animal skeleton taken from the bottom of an ocean. Like many organisms, the air fern is difficult to classify by appearance alone. It is created as many tiny bryozoan animals form a common skeleton around themselves, and it remains after the animals within it die. It is dyed green to increase its resemblance to a plant.

Divide the class into teams of four and tell them you have some pictures of plants and animals for them to see. Enlist the aid of three children to give one set of Plant and Animal cards and one sort mat to each team.

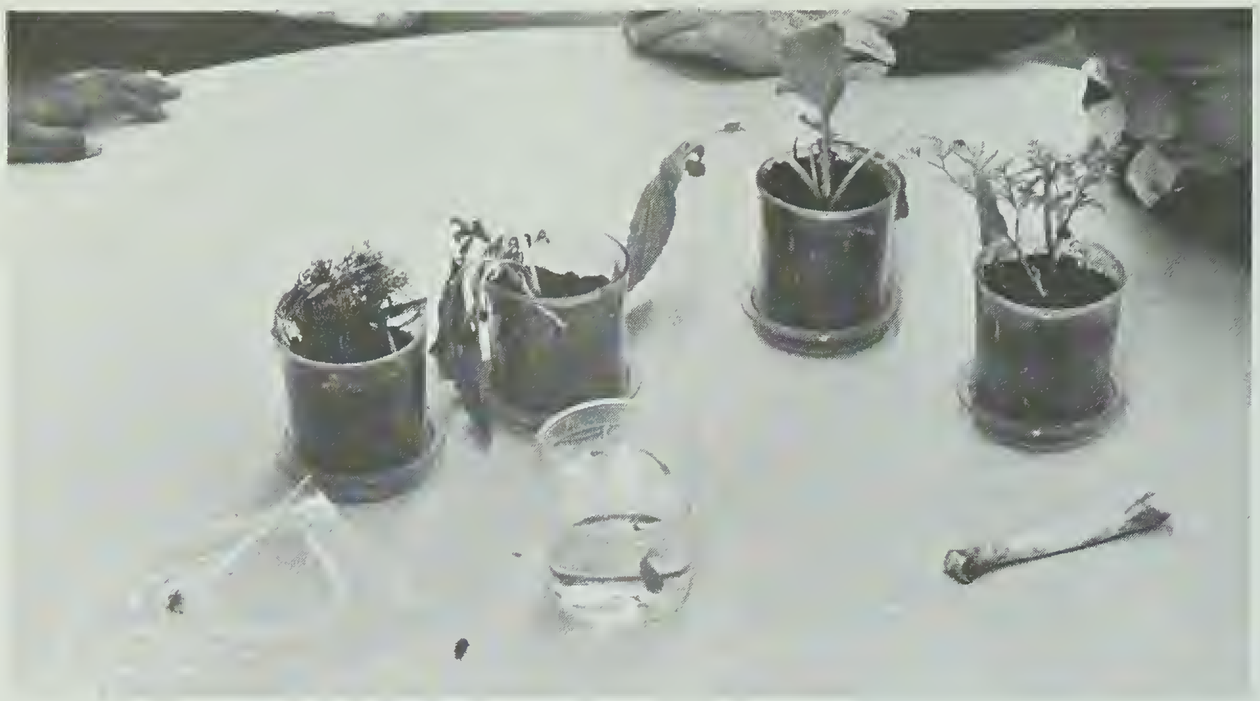
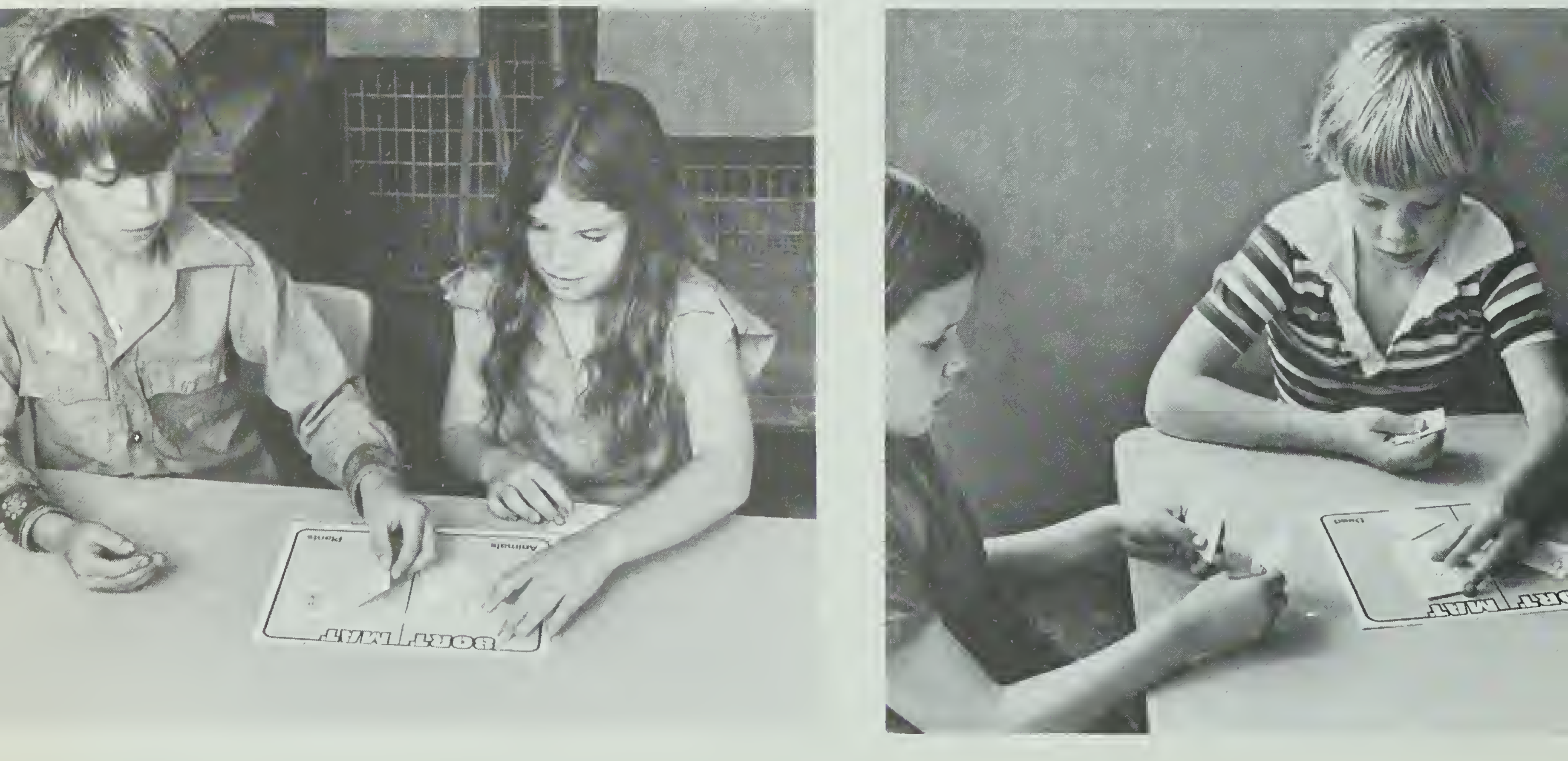


Figure 3-1. Separating plants and animals.

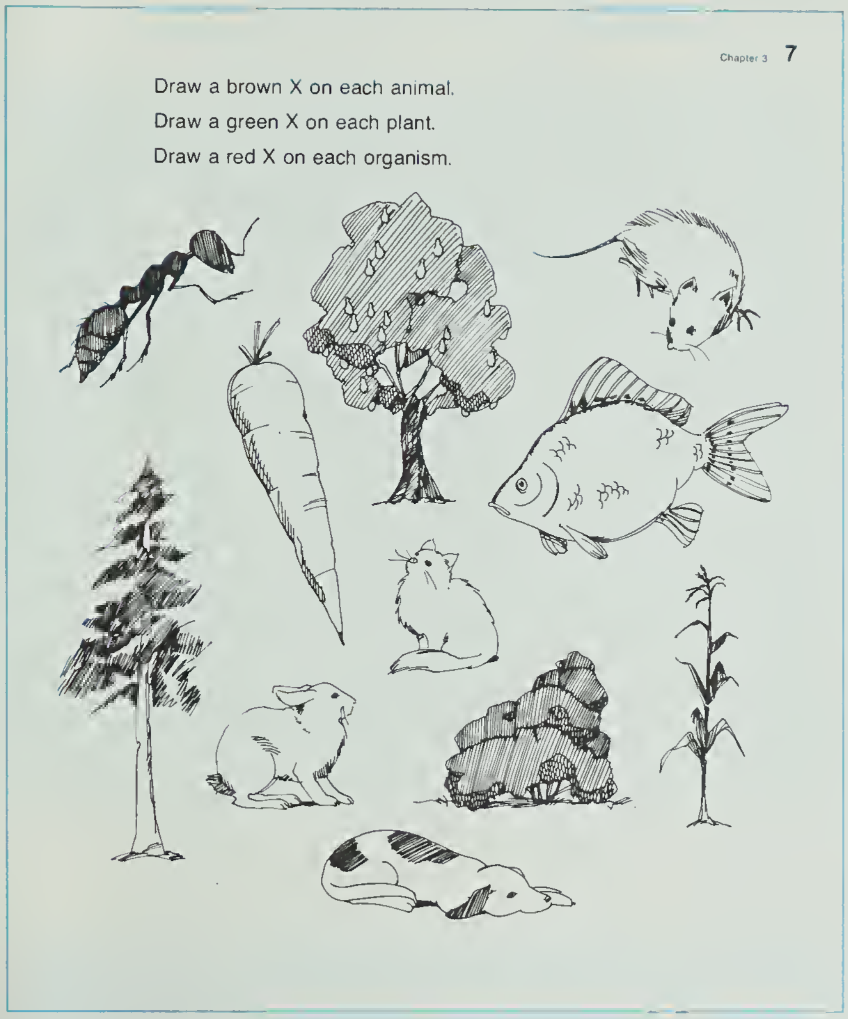
Using the green side of the sort mat, have the children sort their cards into the two areas—plants and animals. As you visit each team, help students who are having trouble.

When most of the children seem to have properly grouped their cards according to plant and animal, have them turn their sort mat over to the yellow side. Encourage them to sort their cards again using the groups printed on the mat. Help those who are unable to read. The way the children arrange their cards on this side of the mat will reveal their understanding of both living and dead plants and animals.

Figure 3-2. Using the sort mat and Plant and Animal cards to classify organisms as *(left)* plant or animal and *(right)* living or dead.



Using student manual page 7. This page may be used to provide experiences in differentiating among plants, animals, and organisms. The children's responses will provide you with feedback about their understanding of these concepts.

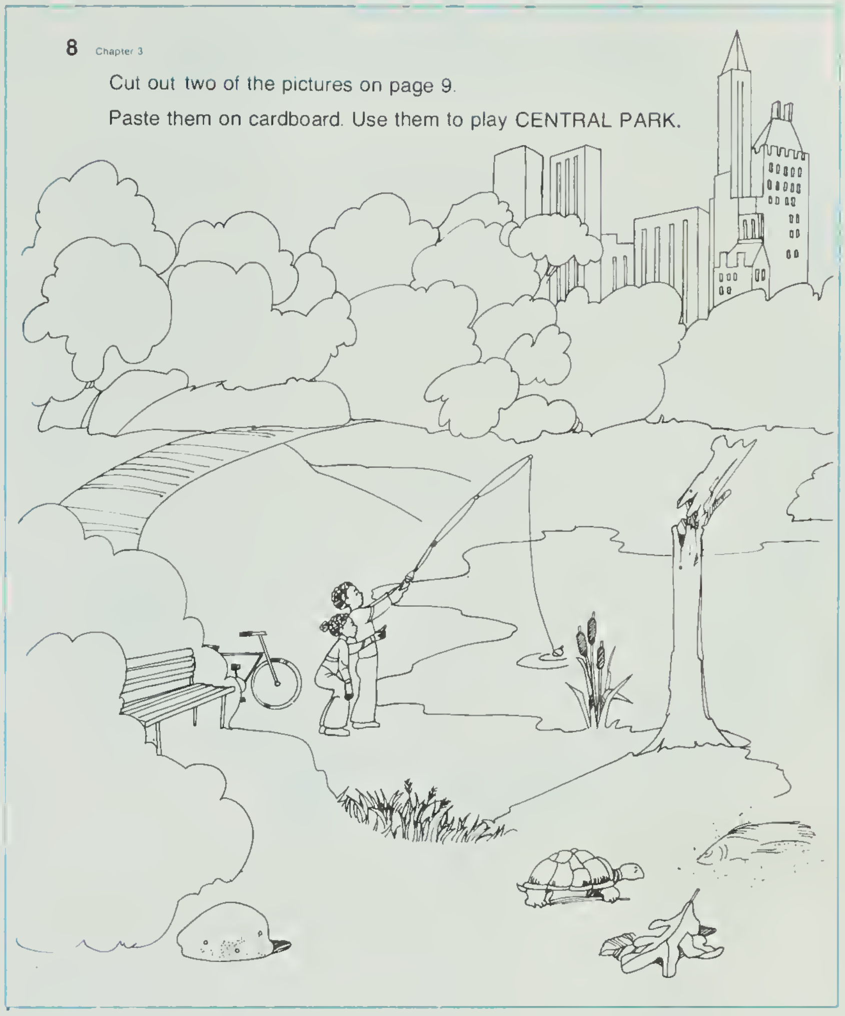


Chapter 3 7

Draw a brown X on each animal.
Draw a green X on each plant.
Draw a red X on each organism.

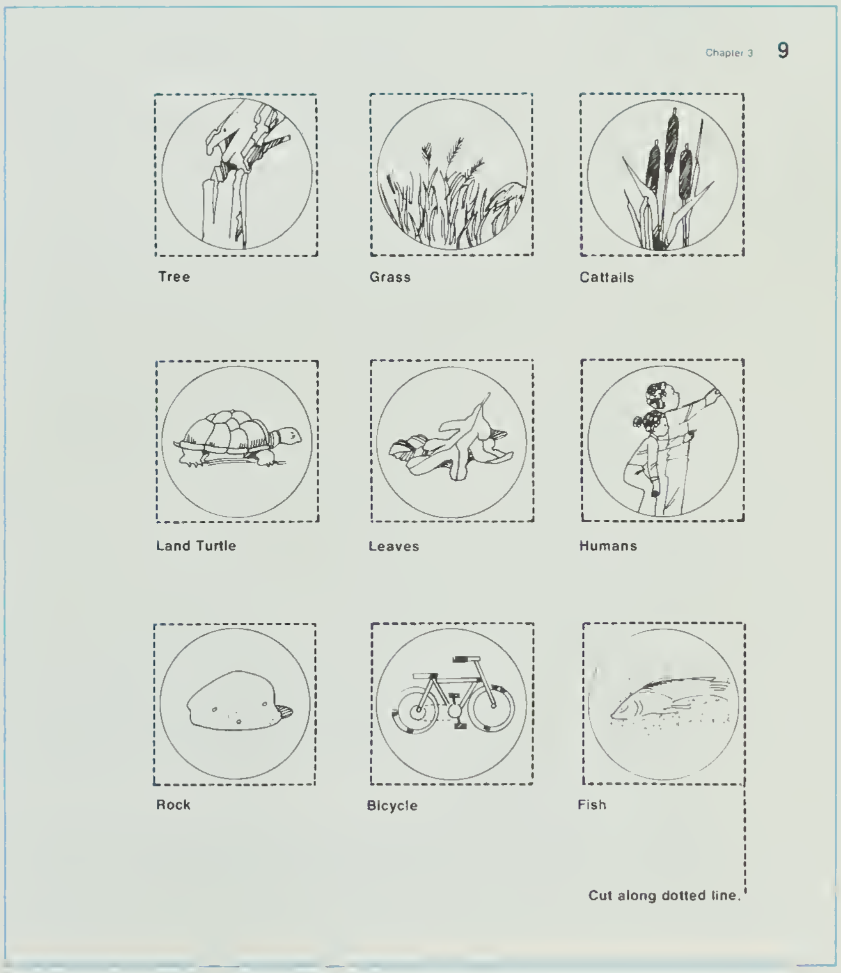
Using student manual pages 8 and 9. Divide the class into 5 teams and give each team a Central Park gameboard. Have each child cut out at least 2 of the pictures on student manual page 9 and glue or paste them onto a cardboard backing. These will be markers for a game. Be sure that they have some "living" (grass, cattails, turtles, and humans), some "dead" (tree, leaves, and fish), and some "nonliving" markers (rock and bicycle).

Playing the Central Park game. Show the children one of the gameboards and tell them they will place all their team markers at the center when they get their gameboard. Tell them that they must each make certain decisions about their objects (the markers) in order to move the object from the center to the outside edge. Explain that when they reach the outer ring they will know they made the right decisions if the marker ends up in the correct space on the outer ring. Deciding which space is "correct" will stimulate more discussion.



8 Chapter 3

Cut out two of the pictures on page 9.
Paste them on cardboard. Use them to play CENTRAL PARK.



Chapter 3 9

Tree
Grass
Cattails
Land Turtle
Leaves
Humans
Rock
Bicycle
Fish

Cut along dotted line.

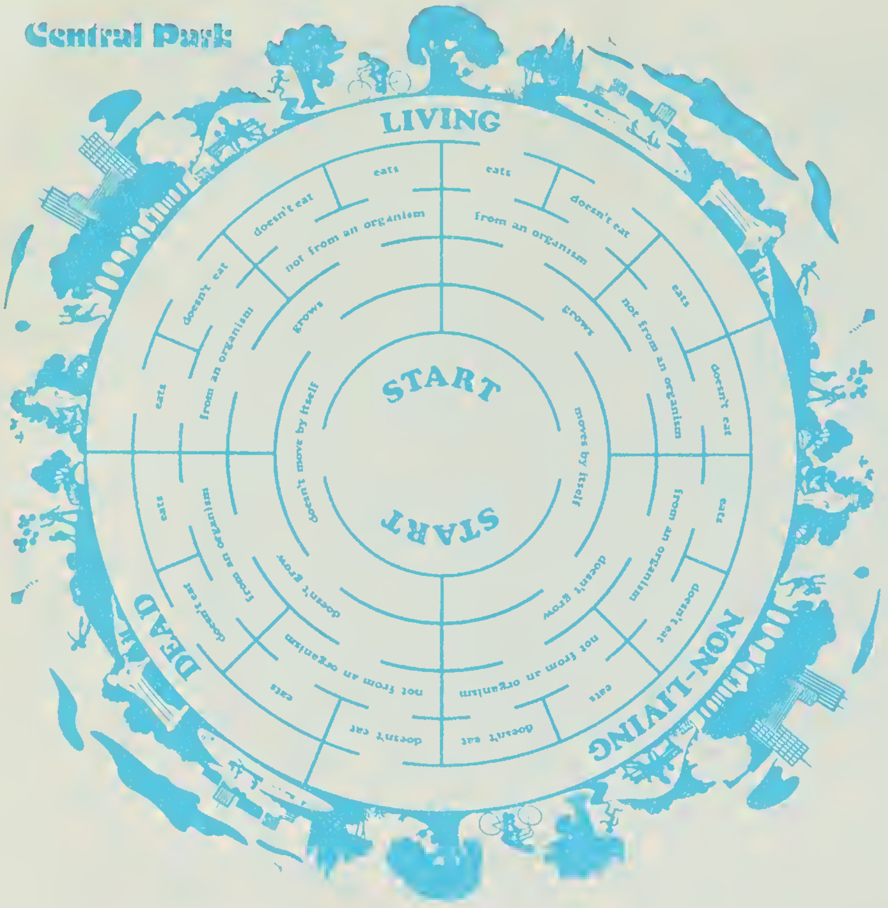


Figure 3–3. The Central Park gameboard.

- Distribute a Central Park Gameboard to each team and ask the students to lay it flat on the floor or a table.
- The students should place their markers on the center section of the gameboard.
- One student should examine one of his markers and decide if it represents an object that moves or does not move.
- If the student thinks the object can move by itself, the marker is placed into the MOVES BY ITSELF section.
- The same child then must decide if his illustrated object eats or doesn't eat, and he moves the marker through an opening into the appropriate section.
through an opening into the appropriate section.
- He continues making decisions and moving his marker through openings into the other rings until the marker is in the outermost ring.
- The final position of the marker will reveal whether the object is living, dead, or non-living.
- The student to the left now moves her first marker before entering each ring in the same fashion.
- When each student on the team has moved one marker, have the first child move his second marker. Continue in this way until the team has used all 9 markers.

Other members of the team usually watch this operation very carefully and often suggest the pathway they think is correct for the different objects depicted on the markers. In this way each team member becomes involved with nearly every section.

If you think your children will have trouble playing the game you may post the gameboard on the chalkboard, make up a demonstration marker, and let the children tell you how to move the marker from the center to the outside ring.

Note. In classroom trials we have tried alternating turns with each student, but found the impatience between turn-taking to be a problem. You may, however, have success with alternate turn-taking.

OPTIONAL ACTIVITY

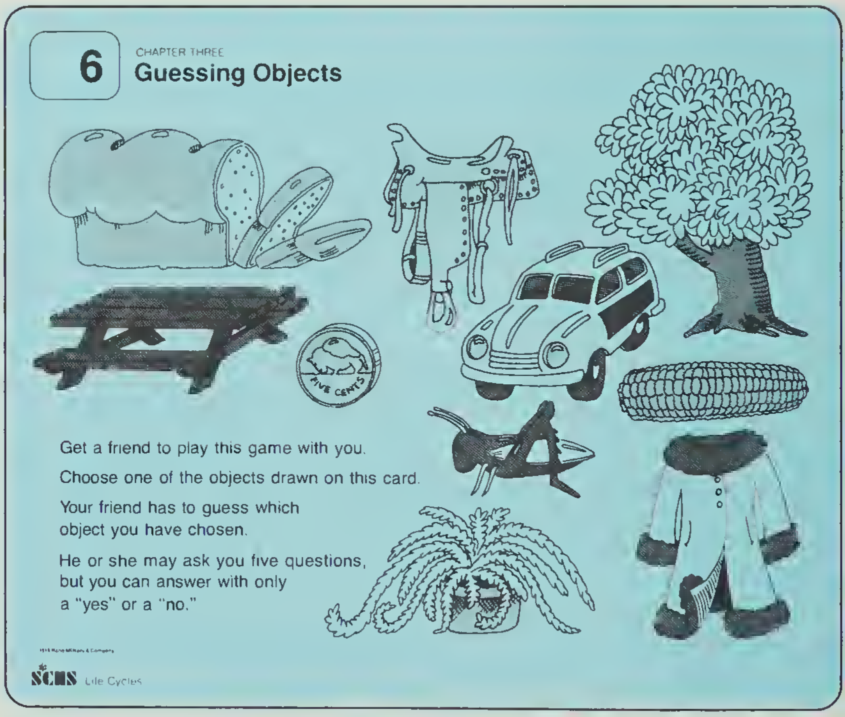
Plants and animals outdoors. Have the children observe the landscape outside the classroom window and list the plants and animals they see.

EXTENDING YOUR EXPERIENCE CARDS

6. Guessing Objects. You may have to help the children with the rules if their reading level does not allow them to understand.

Two to four children may play at a time. Additional illustrated objects may be selected from magazines or the children's imaginations.

Children who ask questions such as "Is it living?" or "Is it dead?" will reach their goal faster than those who start guessing objects without narrowing their choices first.



6

CHAPTER THREE

Guessing Objects

Get a friend to play this game with you.

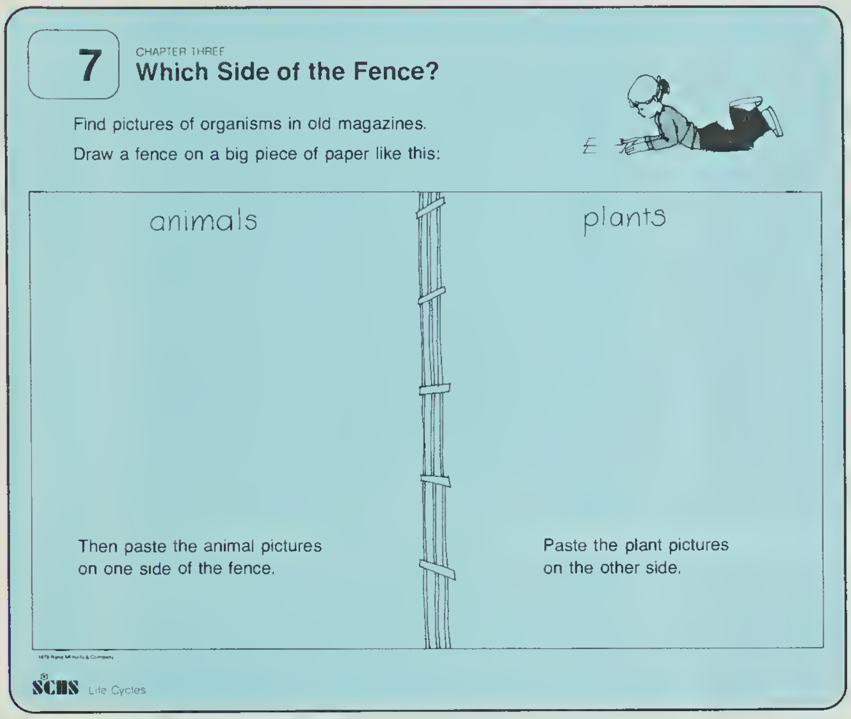
Choose one of the objects drawn on this card.

Your friend has to guess which object you have chosen.

He or she may ask you five questions, but you can answer with only a "yes" or a "no."

FIVE CENTS
SCIIS Life Cycles

7. Which Side of the Fence? You will need to provide some old magazines or other expendable printed matter with pictures of both plants and animals. Scissors, paste, and construction paper backing are also needed. Children who need more practice differentiating plants and animals will benefit from this activity.



7

CHAPTER THREE

Which Side of the Fence?

Find pictures of organisms in old magazines.

Draw a fence on a big piece of paper like this:

animals

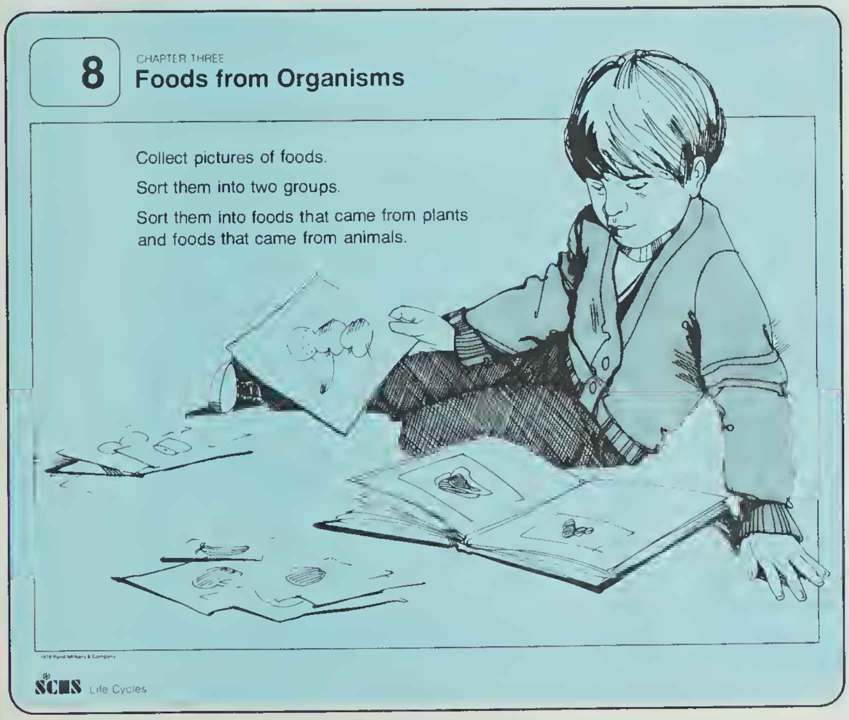
plants

Then paste the animal pictures
on one side of the fence.

Paste the plant pictures
on the other side.

SCIIS Life Cycles

8. Foods from Organisms. The children will need magazine pictures or grocery store advertisements to cut out in order to sort them into plants and animals.



8

CHAPTER THREE

Foods from Organisms

Collect pictures of foods.

Sort them into two groups.

Sort them into foods that came from plants
and foods that came from animals.

SCIIS Life Cycles

Extending Your Experience cards 1-8 are now available for the children's use. For materials needed, refer to the equipment list accompanying the set of cards.

CONCEPT / PROCESS EVALUATION

If you choose to evaluate the children's understanding of the distinctions among the concepts *alive, dead, plant,* and *animal,* turn to page 94 of the evaluation section at the back of the guide.

Part Two

RAND McNALLY

SCIIS

From Seeds to Plants

OBJECTIVES

To conduct experiments with plants illustrating development and growth.

To arrange illustrations of plants in various stages of development in order from seed to adult.

To find, plant, and successfully grow seeds other than those in the kit.

BACKGROUND INFORMATION

You might begin the study of a flowering plant's life cycle anywhere, but the seed stage is usually the most convenient. By planting seeds, watching them sprout and mature into plants, then seeing the plants flower and set new seeds, children can rather quickly see an organism's entire life cycle.

A seed contains both the embryo of a new plant and some food that sustains the plant until it can begin producing its own. Like an animal embryo, the plant embryo results from fertilization of a female reproductive cell (in an ovule) by a male reproductive cell (in pollen). Thus a seed contains genetic material from two sources: either from two parent plants of the same kind (cross-fertilization) or from the male and female portions of one plant. A plant embryo forms within the ovule. As the embryo continues to develop, a protective, thick outer wall, or seed coat, forms. At this stage, the ovule is called a seed.

A part of the pistil may now enlarge around the seed, forming a fruit. Such a fruit can be very large as evidenced by squash and watermelon or smaller as seen in apples, pears, and cherries. The term *fruit* applies to all plant ovaries even though a grocer usually refers to fruits like peppers and tomatoes as vegetables.

Under the right environmental conditions, germination occurs. The plant embryo undergoes a change resulting in the *development* of tiny plant parts—roots, stems, and leaves—making up a seedling. The root usually appears first, followed by the seed leaves and the stem. Following the development of these seedling parts, the plant begins a period of *growth*, during which all of its parts enlarge. Unlike development, which involves the production of new parts, growth is merely an expansion of the parts already present.

When a seed-producing plant reaches a certain age and the conditions are right, it develops flowers. These contain stamens that produce pollen and one

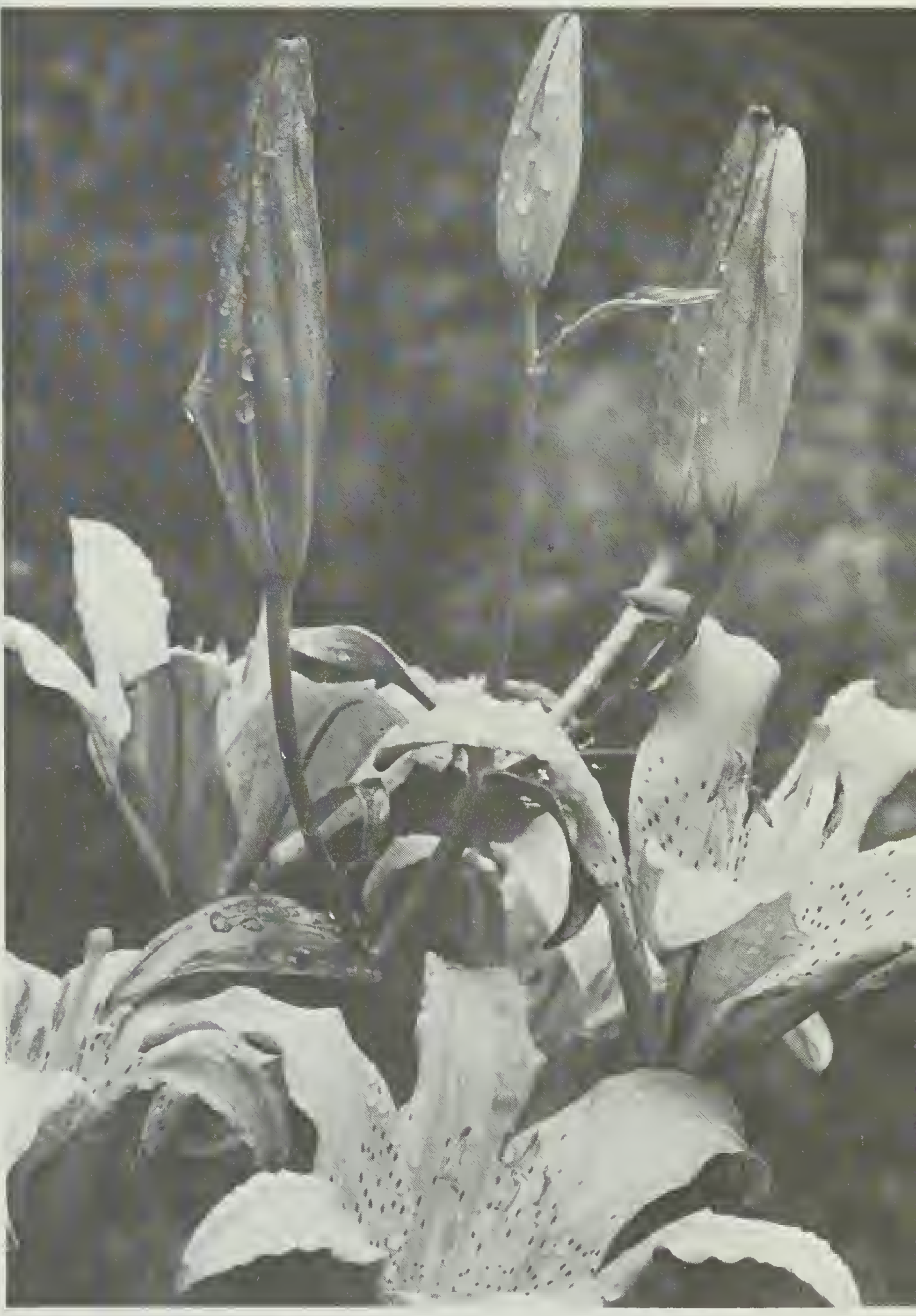


Figure II-1. Lily development.

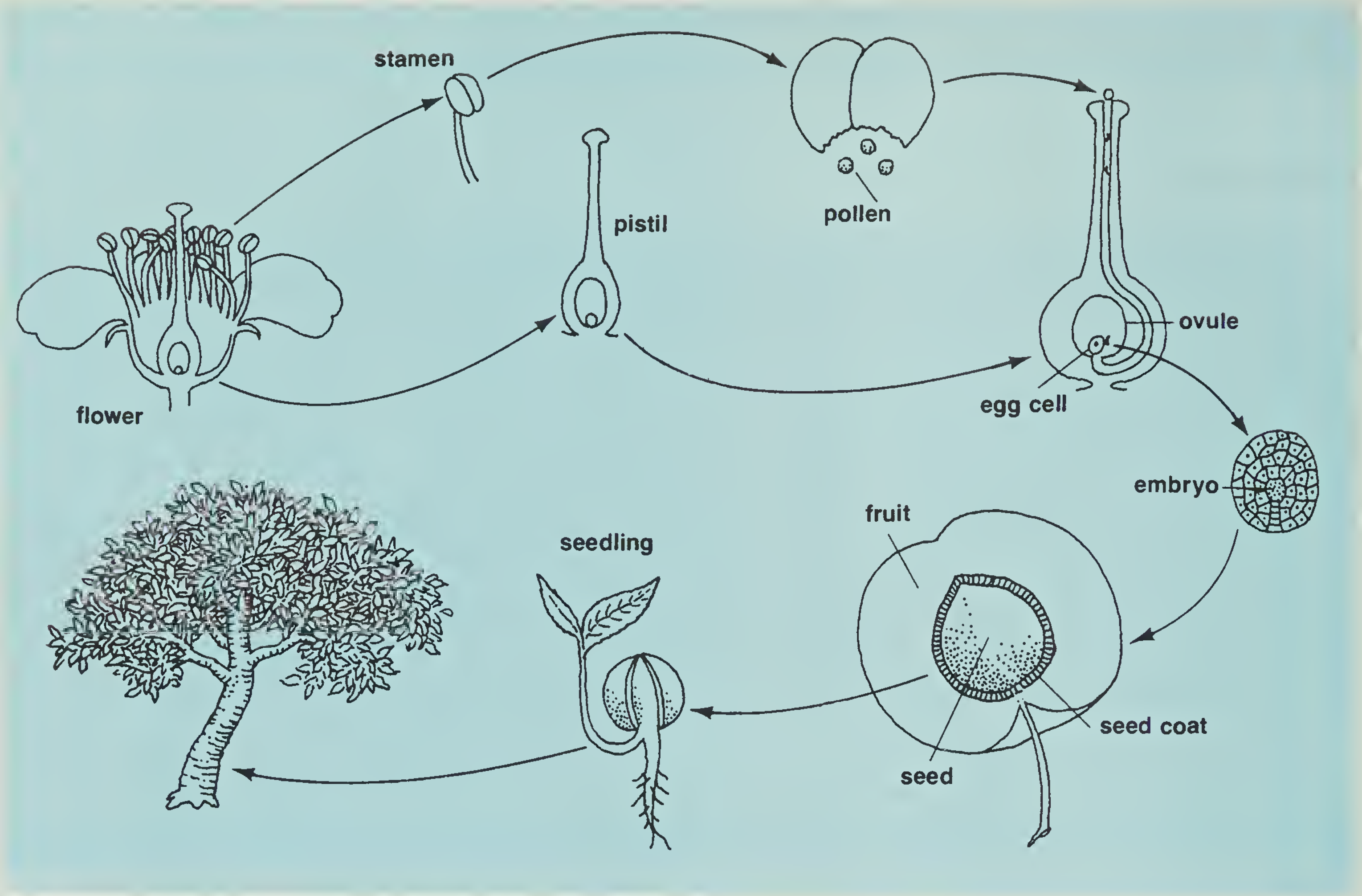


Figure II-2. Life cycle of a flowering plant.

or more pistils containing ovules. After the pollen is transferred to an ovule of the same plant, or of another plant of the same kind, fertilization occurs and a seed is formed. When a flowering plant has gone from seed to plant to seed, it has gone through a complete life cycle.

OVERVIEW

In Chapter 4, "Where Do Seeds Come From?" the children search through different fruits to find seeds. In Chapter 5, "Planting Seeds," the fruit seeds are planted to test whether they are alive. In Chapter 6, "Development and Growth of Plants," the children learn concepts based on their experiences. In Chapter 7, "Experiments with Plants," children devise and conduct experiments having to do with development and growth questions that arose earlier. This is a discovery activity for the development and growth concepts. In "The Great Seed Hunt," Chapter 8, children search for and discover a wide variety of seeds which they then test to determine if the same kind of seed always produces the same kind of plant. The concept of genetic identity, though not the formal term, is established.

GETTING READY

You will need to buy fresh fruit for Chapter 4. (See the "Teaching Materials" list on page 21.)

Prepare some plants by germinating about 100 bean and 100 corn seeds about one week before you plan to conduct Chapter 7. To do this, thoroughly moisten about four handfuls of vermiculite in each of two 8-liter terrariums. Distribute the contents of two packages of corn seeds over the vermiculite in one terrarium and the contents of two packets of bean seeds in the other. Cover the terrarium with the lids provided.

Observe these seeds every other day to be sure they do not become either moldy or too dry. The germination process uses quite a lot of water, so you will need to keep the vermiculite moist. However, rotting seeds or mold may occur when there is excessive moisture around the seeds. Allow fresh air to enter the terrariums when you are checking the vermiculite.

4 Where Do Seeds Come From?

SYNOPSIS

Children search through various fruits for seeds.

Suggested time: *one class session, plus about fifteen minutes' advance preparation time*

TEACHING MATERIALS

For each child:

student manual page 11

For each team of two children:

Drawer 2

1 tray

For the class:

1 piece of chart paper*
1 felt-tip pen*
fresh fruits (2 bananas; 8 apples or green peppers; 4 tomatoes or cucumbers; 32 bean pods, pea pods, grapes with seeds, or a pumpkin or squash)*
knife*
paper towels*
chart paper*
transparent tape*

* provided by the teacher

NOTE
Canned whole green beans can be used in this activity if necessary, but seeds from fresh fruits will be needed for Chapter 5.

ADVANCE PREPARATION

For a class of thirty-two children, you will need the amounts of fruit listed in "Teaching Materials." Select five or six kinds of fruit that can be easily handled by the children and easily sectioned.

Have some children help you prepare the fruit for use. Each child will need a piece of each kind of fruit, and that section should contain seeds. As you cut the fruits, have a few children prepare a tray for each class member (Figure 4-1). Allow about fifteen minutes for this preparation.

TEACHING SUGGESTIONS

Children continue working with plants in the discovery phase of the learning cycle. They also begin the long *life cycle* exploration phase, which extends over many chapters. Invention of the term will not occur until Chapter 13.

Discovering seeds. Ask the children what they know about seeds. You will probably get an array of answers and descriptions. Accept all their descriptions and then ask where they think seeds come from. Suggestions such as the store, flowers, or from the ground are common.

Now distribute a tray of fruit sections to each team of two children or have some helpers assist you.

Figure 4-1. You should probably slice the fruit yourself.

Goodyear Sale!

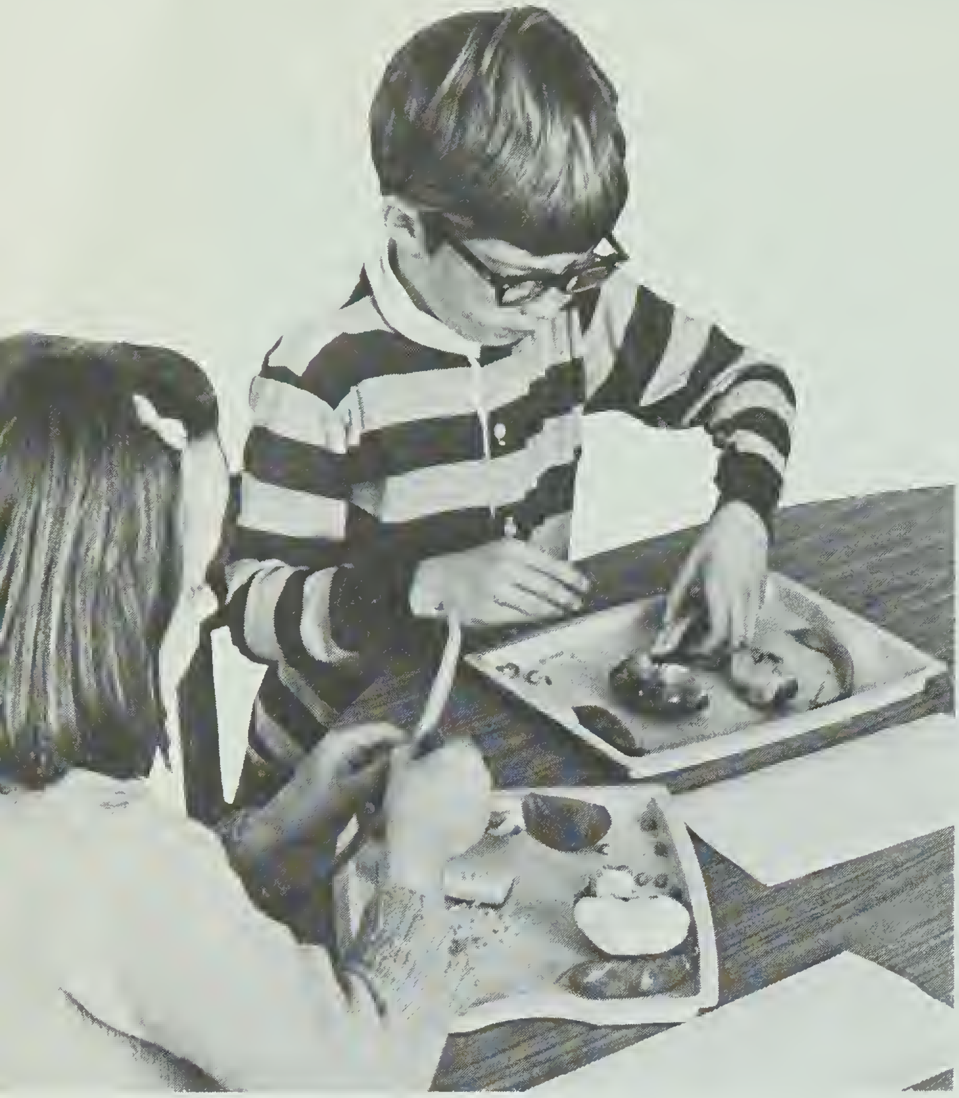


Figure 4-2. Searching for seeds in fruit.

Entire preparations of fruits have been known to disappear when personal servings are delivered to the children. You may want to tell them they will be looking at these plant parts today and that if they eat them they will not be able to do the activity.

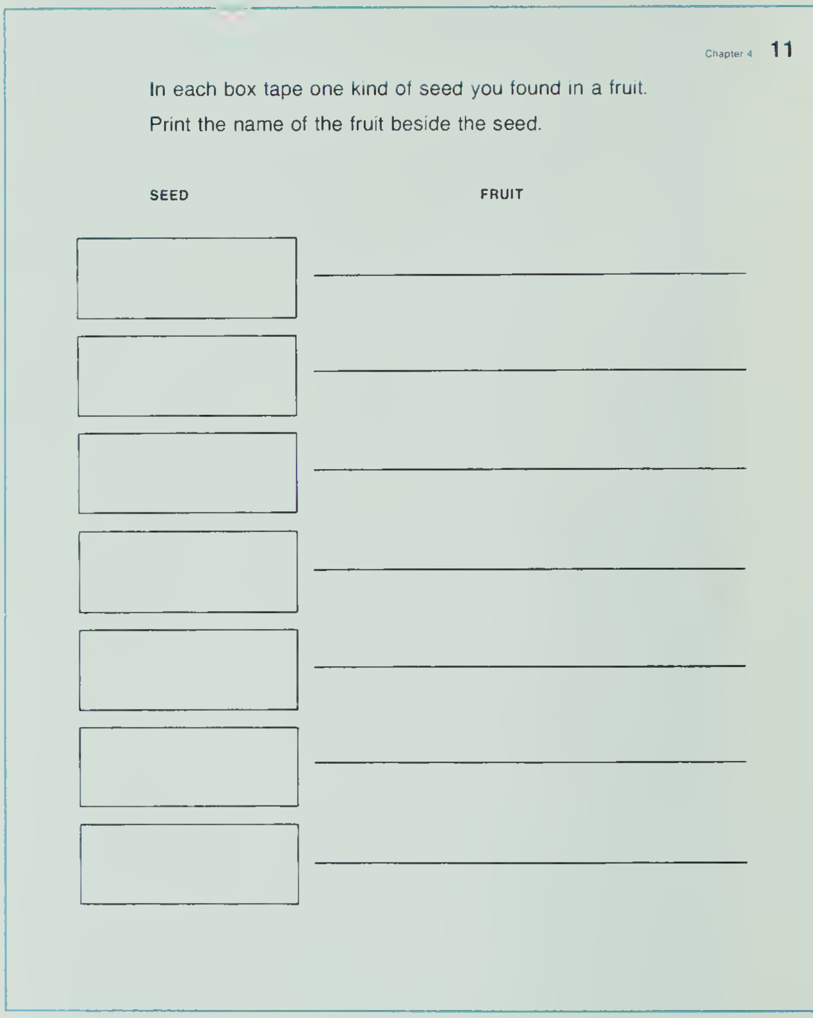
As the trays are distributed, tell the children to search for seeds in the fruit and to remove as many seeds as they can. While they are locating and extracting the seeds, walk around the room so they can show you what they have found. Encourage them to examine the seeds and to figure out which plants have the most seeds.

Discussion. When most of the seeds have been found, ask some questions that will allow the children to share their discoveries:

- Which kind of seed is the biggest? The smallest? The longest? The shortest? The roughest? The roundest?
- Which kind of plant had the most seeds? The least seeds?
- Are the seeds colored like the rest of the plant parts?

A new term. Tell the children there is a name for the part of a plant where the seeds are found. It is called a *fruit*. You might mention here that we usually call beans, peas, cucumbers, and tomatoes vegetables. However, they are really fruits because they enclose the seeds.

Using student manual page 11. Before the students clean up, let them record one of each seed type and the name of the fruit from which it came. A different seed should be taped in each box outline and the name of the fruit printed next to its seed.



Chapter 4 11

In each box tape one kind of seed you found in a fruit.
Print the name of the fruit beside the seed.

SEED FRUIT

Question list. Record on a piece of chart paper the children's questions which arose during this activity. One common question is, "Will these seeds grow?" Be sure to save most of the seeds for investigating this question. (Allow the seeds to dry out by storing them on paper towels beneath the light source.) Save the list of questions. In Chapters 6 and 7, there will be opportunities to experiment with the development and growth of plants.

Cleanup. Save all the seeds and discard all the fruit sections, unless you want the children to try drying the fruit as the Indians used to do. (Apples may be sliced thinly, laid on a wire rack to dry in the sun, and later eaten.) Clean the trays and save them for future use.

OPTIONAL ACTIVITY

A class garden. Have the children plant an indoor garden, using seeds purchased at a store but similar to those they examined in the fruits.

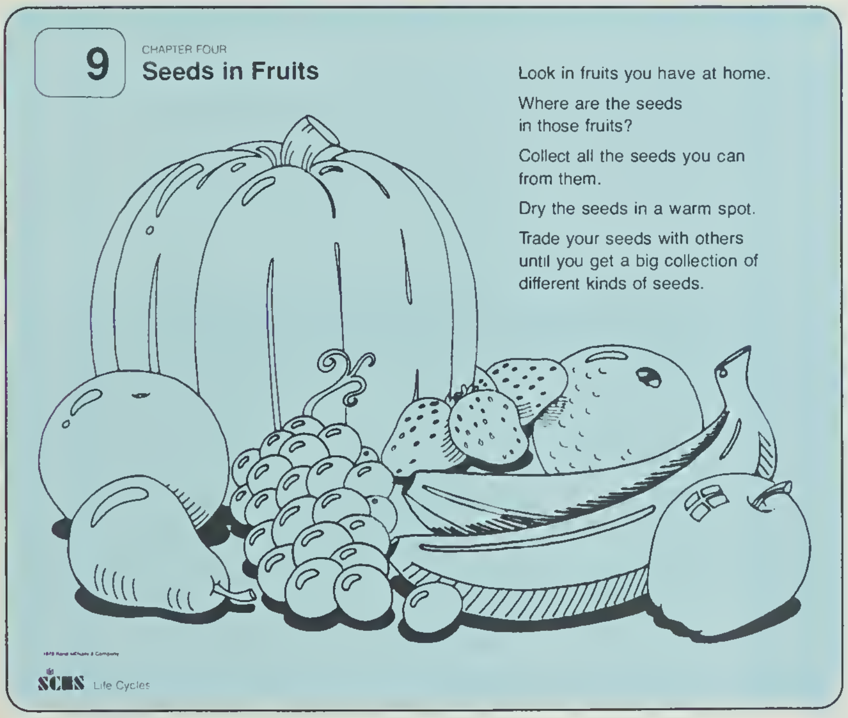
A simple indoor garden can be made on a window sill, on a table near a window, or even on the floor. For the long sides of the frame, obtain two 5 cm x 20 cm (2″ x 8″) boards of the same length, anywhere from 1.5 m to 5.5 m (5′ to 18′) long. (New lumber is unnecessary.) For the short sides of the frame, get two more 5 cm x 20 cm boards of equal length (0.5 m, or 2′, perhaps).

Nail all four corners together and cover the entire frame with a single piece of heavy plastic sheeting from a hardware store.

Put soil on top of the plastic, moisten it, and plant the seeds. The garden will do well. A few roots will emerge here and there, much to the children's delight.

EXTENDING YOUR EXPERIENCE CARDS

9. Seeds in Fruits. No special preparation is necessary. This card may lead the child into card 10.



9

CHAPTER FOUR

Seeds in Fruits

Look in fruits you have at home.

Where are the seeds
in those fruits?

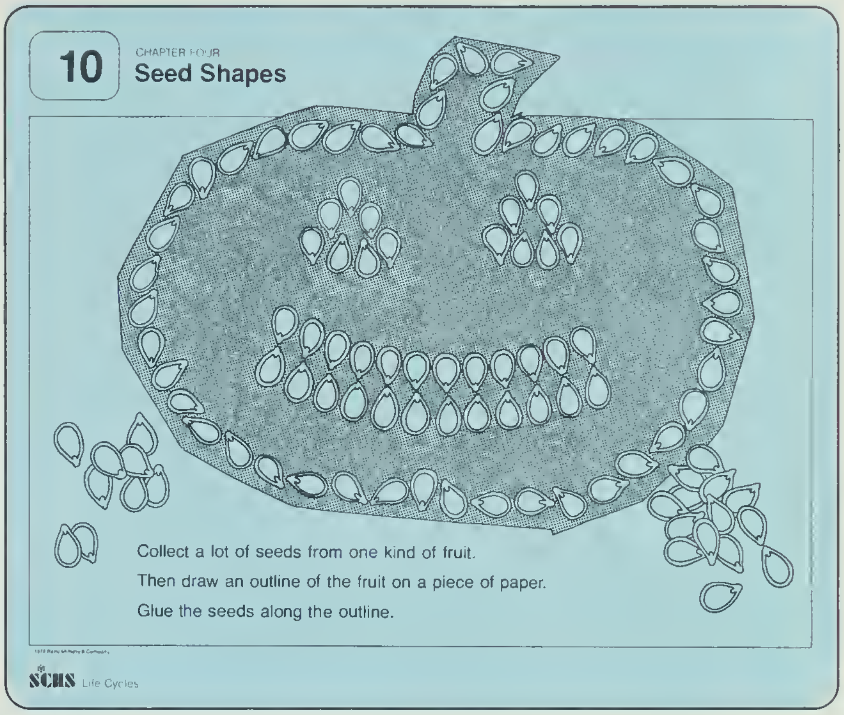
Collect all the seeds you can
from them.

Dry the seeds in a warm spot.

Trade your seeds with others
until you get a big collection of
different kinds of seeds.

SCIS Life Cycles

10. Seed Shapes. For this activity, the child will need many seeds from one kind of fruit, paper, and glue.



10

CHAPTER FOUR

Seed Shapes

Collect a lot of seeds from one kind of fruit.

Then draw an outline of the fruit on a piece of paper.

Glue the seeds along the outline.

SCIS Life Cycles

5

Planting Seeds

SYNOPSIS

Children plan an experiment to determine if the seeds from their fruits will become plants.

Children plant seeds and grow plants.

Suggested time: *one class session, followed by observations over a two-week period*

TEACHING MATERIALS

For each child:

student manual page 12

For each team of two children:

Drawer 2

1 tray

Drawer 5

2 planter cups
2 planter bases

For the class:

soil‡
seeds from opened fruits (from Chapter 4)
list of questions (from Chapter 4)
cutoff milk cartons*

Drawer 4

3 tumblers

Drawer 5

6 water sprinklers

* provided by the teacher
‡ Sand and Soil box

ADVANCE PREPARATION

Set up three distribution stations, each containing about a third of all the teaching materials.

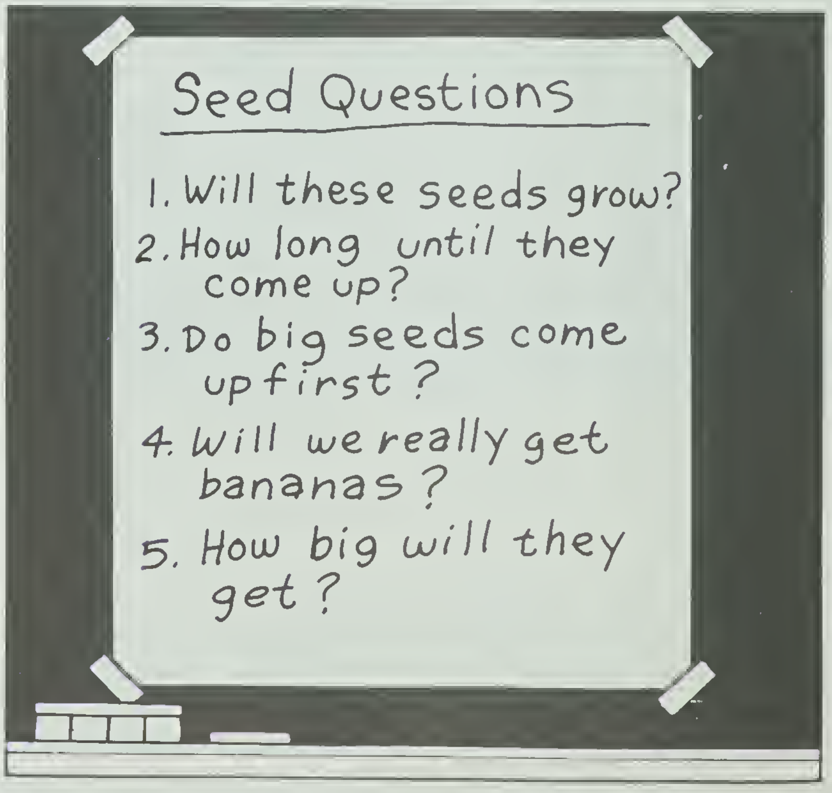
TEACHING SUGGESTIONS

Children continue the discovery activities begun in previous chapters.

Planting seeds. Carry out this activity in order to compare the seeds from the fruits in the previous chapter with those from the packages in the kit (to be planted in Chapter 6). This will help the children make the connection between seeds from plants and those from packages and stores.

- Display the chart paper list of questions from Chapter 4. Such questions on the list as, "Will these seeds grow?" or "How big will they get?" and others can be answered by experimenting.
- Ask the children how they could find out if the seeds they got from the fruits the other day are alive.
- They will probably suggest ideas such as, "See if they grow," "Look it up in a book," "Ask a scientist," and so on.
- Always encourage the ideas that promote finding out through an experiment with real seeds rather than referring to an authority.
- Rather than providing a detailed explanation of what an experiment is, help students plan a way of finding out if their fruit seeds will grow. As they

Figure 5-1.



Seed Questions

1. Will these seeds grow?
2. How long until they come up?
3. Do big seeds come up first?
4. Will we really get bananas?
5. How big will they get?

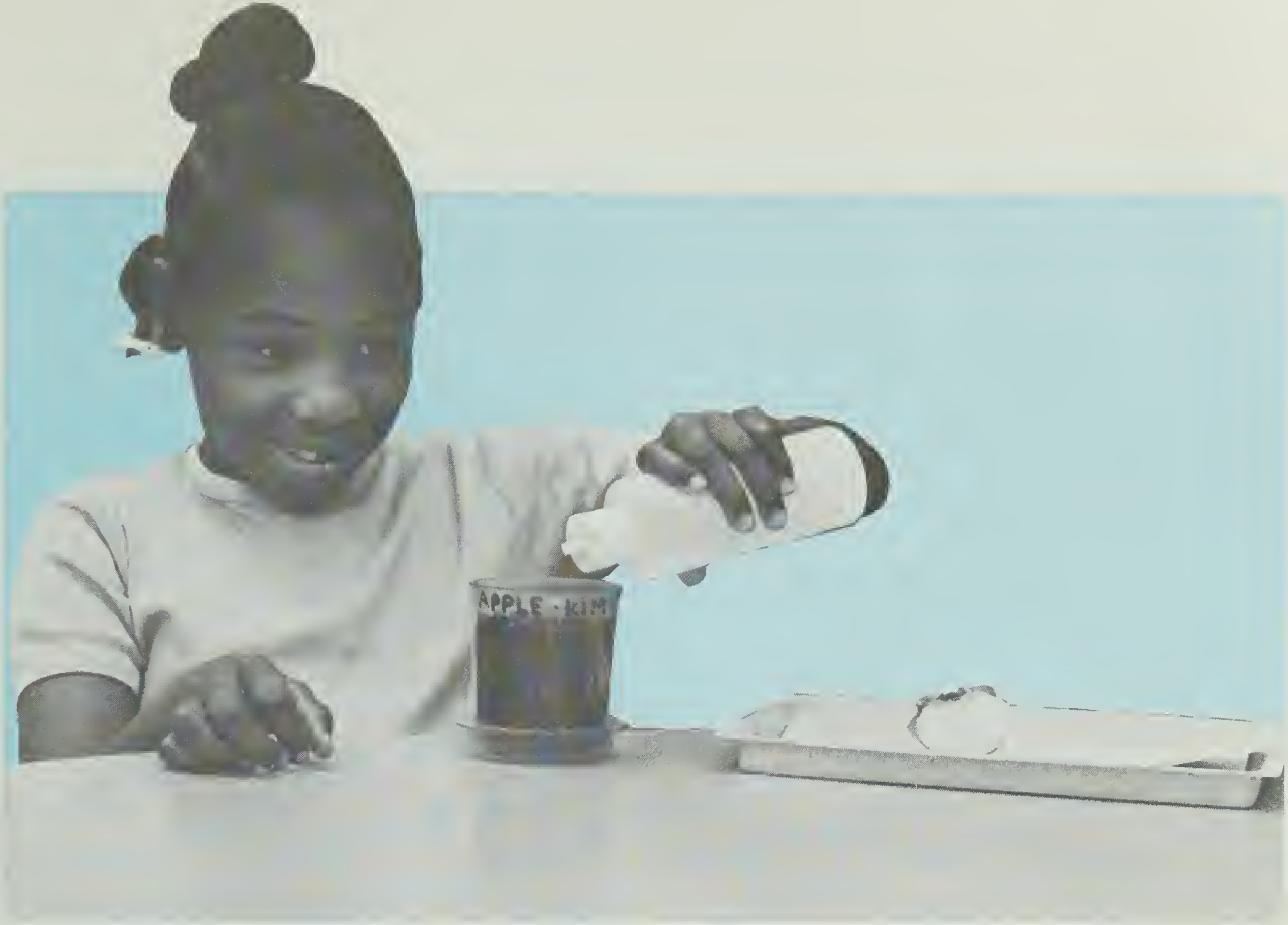


Figure 5-2. Finding out whether fruit seeds grow.

suggest "planting the seeds to see if they'll grow," for example, it will be helpful for you to quickly sketch an illustration of their plan on the chalkboard.

- Invite volunteers to suggest how an experiment can be done. Ask them what materials they need and sketch the physical arrangement of the experiment on the board.
- When the children have worked out a plan, point to your sketch and say that this way of finding an answer is called an *experiment*.
- Have the children get the materials they need and plant their seeds.
- As you walk around the room, suggest watering the soil until it is moist enough to darken the soil but not enough to drip water when a pinch is squeezed.
- You may have to remind some children to cover the seeds with soil.
- Remind the children to label their planter cups, by penciling their names on the frosted rim of each cup, before placing the planters together on a table.

Using student manual page 12. This is an open-ended page which you may use as you see fit. You might want to have the children sketch or describe their experiment. Or they can write a simple description of the experiment, the results, or both.

12 Chapter 5

My experiment with seeds from fresh fruit.

Observing results. Probably few of these seeds will grow, both because many of the fruits sold in stores are picked before the seeds mature and because some types of seeds must dry out and age more before they will germinate. You might save some unused seeds and try planting them after they have dried for a month or so.

Plan to have the children observe and water the plants every other day (a Monday-Wednesday-Friday schedule is best) for about two weeks. Water as needed. (See "Care of Plants, page 107.)

During the two-week observation period, begin Chapter 6.

When plants appear in any containers, let all the children see them. Have the owner tell which kind of fruit seed is growing.

Have the children decide how their experimental results answered the question, "Will these seeds grow?" Their decision should be based on the evidence they have.

If most of the seeds did not develop into plants and you think they had enough water, light, and heat, solicit ideas from the children about how they think the seeds from these fruits get planted in the natural world. You may have to tell them about fruits being picked before they are ripe.

This discussion often leads to a suggestion that the seeds be aged, dried, the fruits have to rot, etc. Experiments to test these ideas can be planned and carried out by the children.

Cleanup. Transfer any growing plants and the soil to milk cartons either for continued growth or for the children to take home. Put any extra soil back in the soil bags. Clean the planter cups and bases and air dry them.

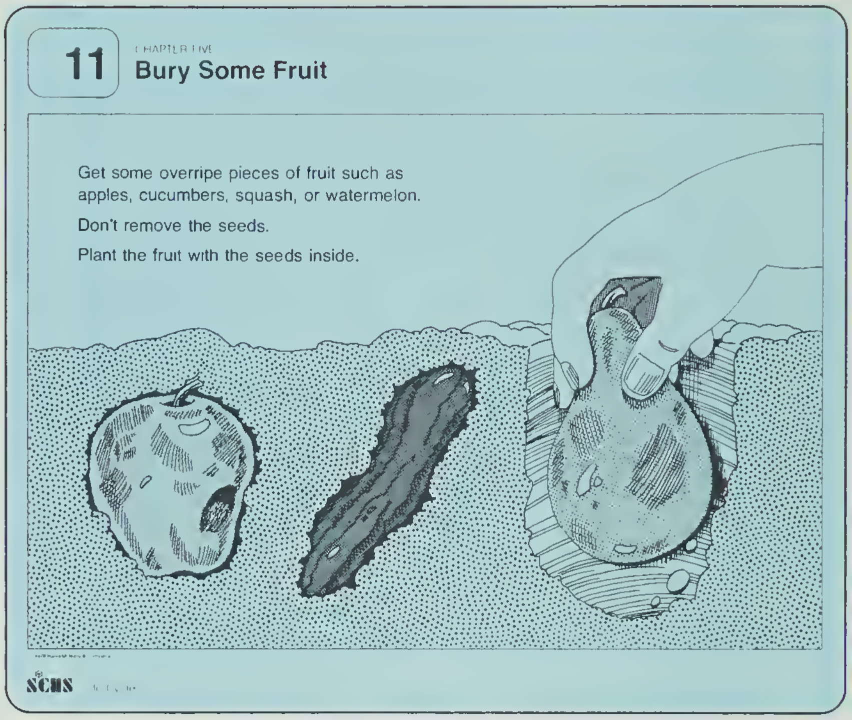
OPTIONAL ACTIVITY

Testing seeds from fallen fruit. Collect fruits which have been homegrown or which have ripened and fallen from a plant. Nearly all such seeds are capable of producing plants.

Compare the seed growth from these mature fruits with that from the grocery store fruits.

EXTENDING YOUR EXPERIENCE CARDS

11. Bury Some Fruit. The children will need some overripe fruits. Planting of the fruit and seeds may be done outdoors or in any of the containers and soil not now in use.



CHAPTER FIVE

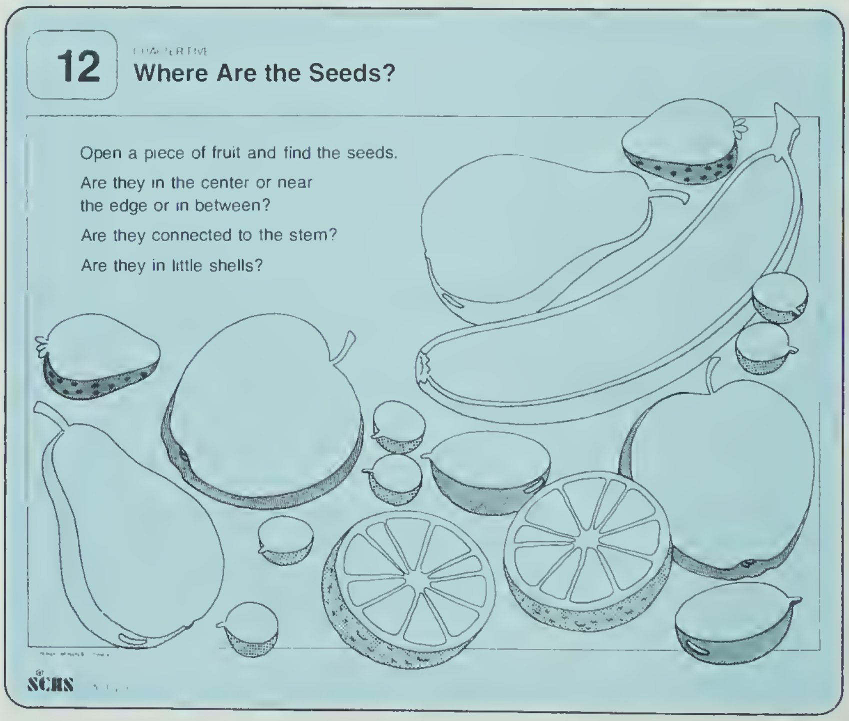
11 Bury Some Fruit

Get some overripe pieces of fruit such as apples, cucumbers, squash, or watermelon.

Don't remove the seeds.

Plant the fruit with the seeds inside.

12. Where Are the Seeds? This activity requires two or more different kinds of fruits. Any fresh fruits will do. Canned string beans, grapefruit sections, or bruised fruit will be fine, too.



CHAPTER FIVE

12 Where Are the Seeds?

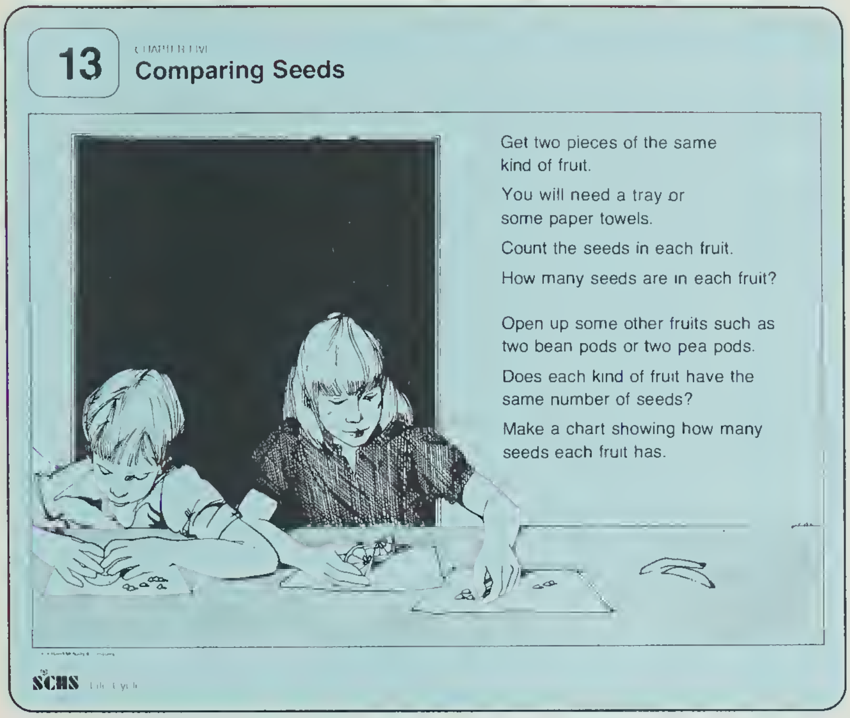
Open a piece of fruit and find the seeds.

Are they in the center or near the edge or in between?

Are they connected to the stem?

Are they in little shells?

13. Comparing Seeds. For this activity, the children need at least two fruits of the same kind in order to compare the seeds in each. Most fruits, with the exception of tomatoes with their many seeds, are satisfactory. Some trays and paper towels will be needed for work surfaces.



CHAPTER FIVE

13 Comparing Seeds

Get two pieces of the same kind of fruit.

You will need a tray or some paper towels.

Count the seeds in each fruit.

How many seeds are in each fruit?

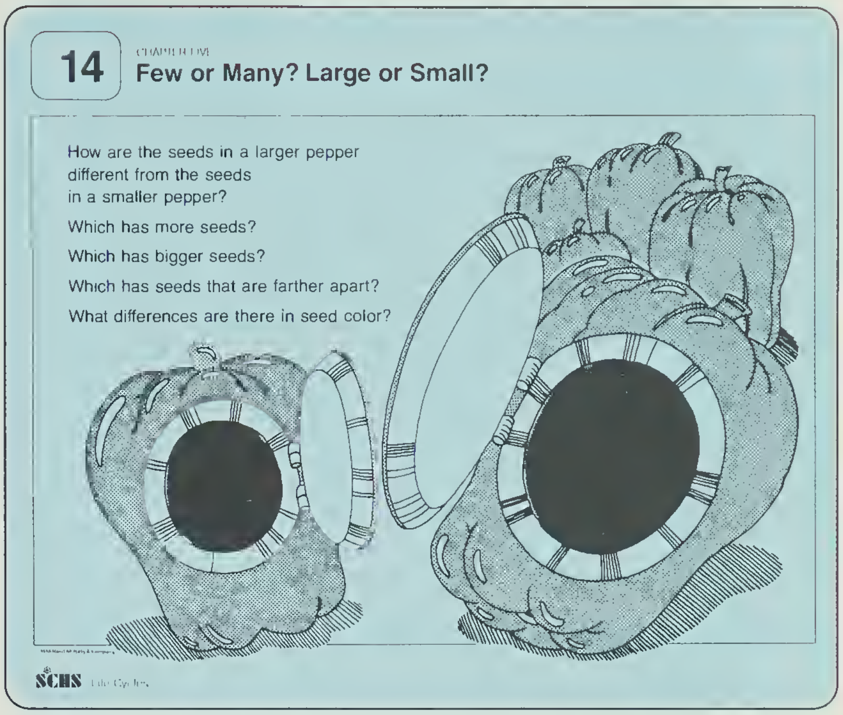
Open up some other fruits such as two bean pods or two pea pods.

Does each kind of fruit have the same number of seeds?

Make a chart showing how many seeds each fruit has.

SCHS Life Cycles

14. Few or Many? Large or Small? For this activity, a large and a small fruit of the same kind are compared. Peppers are excellent fruits for this activity.



CHAPTER FIVE

14 Few or Many? Large or Small?

How are the seeds in a larger pepper different from the seeds in a smaller pepper?

Which has more seeds?

Which has bigger seeds?

Which has seeds that are farther apart?

What differences are there in seed color?

SCHS Life Cycles

6

Development and Growth of Plants

SYNOPSIS

Bean plants are maintained until they complete their life cycles.
Children plant seeds, observe development, and measure growth.

Suggested time: *one session for planting followed by two or three weeks' observation time*

TEACHING MATERIALS

For each child:

student manual pages 13 and 14

Drawer 1

Bean Plant student sheet.

Drawer 3

1 small plastic zip lock bag
1 wire hook

Drawer 5

2 each bean, corn, pea, and squash seeds

For the class:

soil‡
vermiculite‡
transparent tape*
pencils*
scissors*
paper towels*

Drawer 1

Plant Development cards

Drawer 2

2 planter bag supports
1 light source

Drawer 4

3–6 tumblers

Drawer 5

4 labels
4 flowerpots
6 water sprinklers

* provided by the teacher
‡ Sand and Soil box

ADVANCE PREPARATION

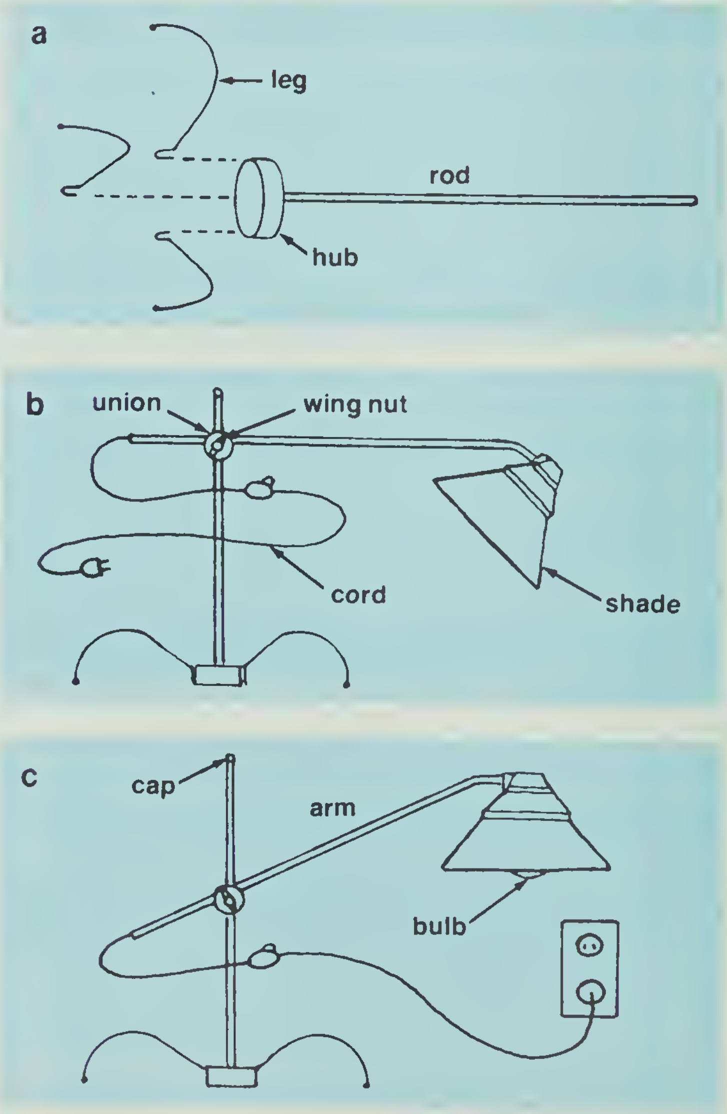
Prepare three distribution stations. At each one, provide seeds, germination bags, vermiculite, water sprinklers, and tape for labels.

You will find a light source partly assembled in the kit. Use the instructions in Figure 6-1 to complete the assembly before beginning this activity.

TEACHING SUGGESTIONS

Seeds are planted in an exploration lesson leading to your invention of the terms *growth* and *development*. As the children observe the growing plants, they also continue the discovery of plant characteristics.

Figure 6-1. *(a)* Firmly push the legs into the bottom of the hub. Set this assembly upright. *(b)* Unwind the cord, loosen the wing nut, and push the rod through the union. *(c)* After lowering the union and rotating the arm, tighten the wing nut. Keep the bottom of the shade parallel to the table. Cap the rod and add the light bulb.



Planting seeds.

- Ask the children what happens to seeds after they have been planted. Listen to their answers to learn what they know so far.
- Then ask if they think all seeds change into plants at the same time or in the same way.
- Without dwelling on these questions, suggest they all plant several different kinds of seeds today in order to find out.
- Show the four types of seeds supplied and list the names on the chalkboard.
- Tell the children they will plant the seeds in a new way so they will be able to see what happens to each kind of seed.
- From one of the distribution stations, get a plastic bag, one of each kind of seed, and some transparent tape. Then label and fill the bag as directed in Figure 6-2.
- Suggest to the children that each of them label a planter bag and plant four different seeds as you just did.
- As you move among the children, look for bags having too much or too little vermiculite and too much water.

Mixing up seeds. Prepare two new planter bags that you will use later with the children. In each bag of vermiculite, insert five each of the four seed types. Mix them up. Later offer the children an opportunity to tell you which of your seeds are which, using their plant-seed reference system. Some of your seeds may also be used to replace plants broken by the children.

When all the planting systems have been assembled and labeled, ask some questions to find out what the children now know about growing plants:

- What will happen next?
- How soon will that happen?
- How many plants will each planting system have in it next week? After two weeks?
- What kinds of plants will we get?

You may be quite surprised at the children's responses. Children in trial classrooms have told us all the seeds will grow into one large plant, that they will get strawberries, that more plants will be in the bag next week, and other such comments. Their problem has a simple cause—they haven't had enough actual experience with these events.

If you jot down some of the answers to your questions now, you will be able to compare their answers to the same kinds of questions if you ask them to do this same activity later. This kind of evaluation has little cultural bias, because any observed growth is primarily related to practical experiences rather than to the amount of reading a child has done.

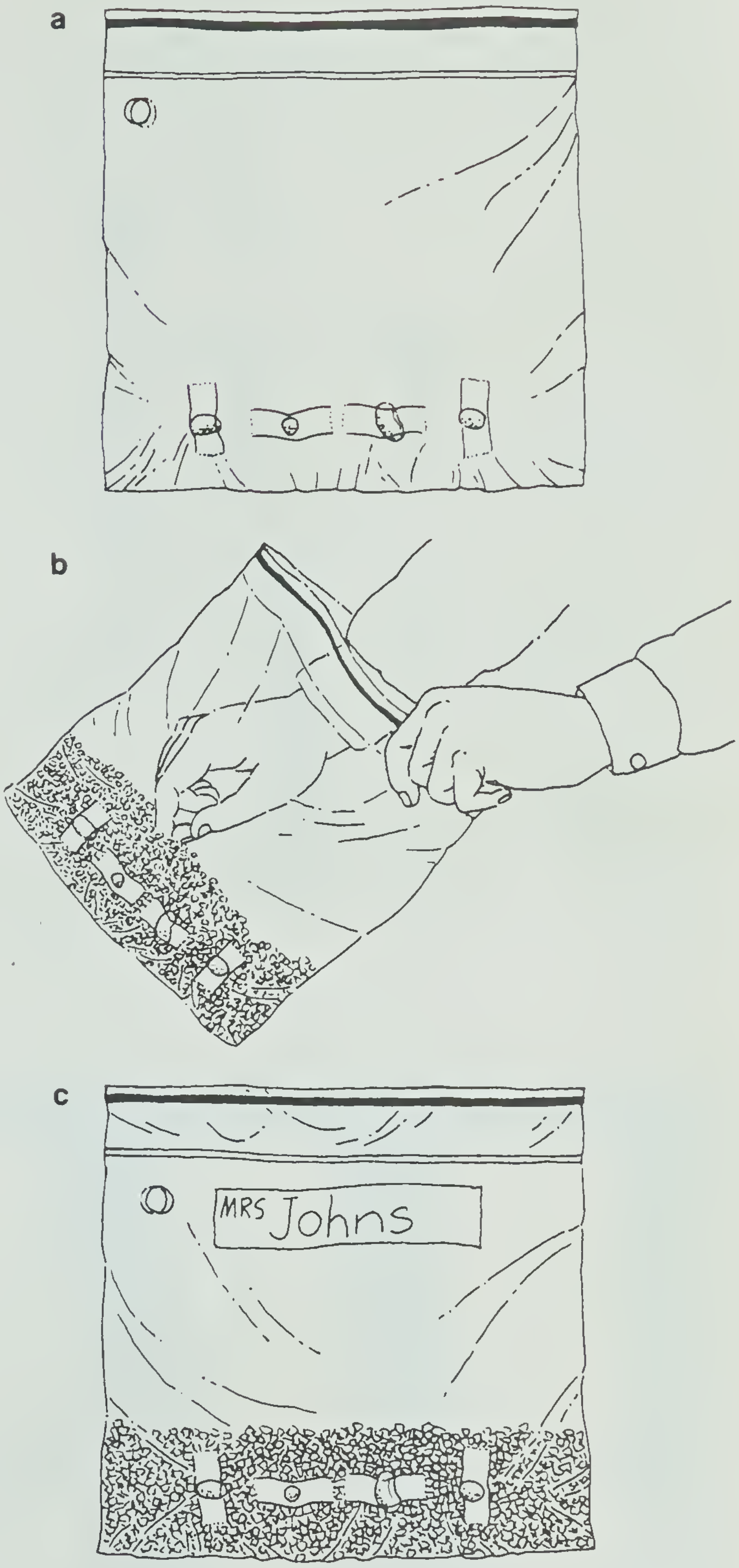


Figure 6-2. *(a)* Lay the bag flat and space one of each seed type across its lower edge. Tape the seeds to the bag. These will indicate where the seeds are planted inside the bag. *(b)* Using a tumbler as a scoop, place vermiculite in the bag to a depth of 1–2 cm (½–1 in). Put one seed of each kind in the vermiculite, directly opposite the matching seed on the outside of the bag. *(c)* After squirting the vermiculite twice with water from the sprinkler, zip the bag closed. Write your name on a label and put it near the top of the bag, but not over the air hole.

Using student manual pages 13 and 14. Use these pages with the children as a record of development over six to eight days. The children can select one large seed, such as the pea, and draw or trace it every two or three days, thus recording its development. (The plants can be removed from the bags.) Or, if you would prefer, they can draw all four plants at whatever times the plants show interesting changes.

Growing plants. After the discussion, ask the children to hang up their planter systems on supports. To do this, weave a wire hook through the hole in the top of the bag. The hook will fit over the planter bag support (Figure 6-3). Store the system with the bags close enough to the light source so the seeds will receive some heat. Plan to let the children spend at least a few minutes of every school day observing the changes in their seeds over the next ten calendar days.

On the next science day, have each child get his or her planter system and a paper towel. Let the children open their planter bags and remove the seeds to see the changes which have taken place. Encourage them to compare the seeds in the planter bag with the seeds taped on the outside. If all of the "planted" seeds have become swollen, no more water should be added to the bags today. If any seeds appear to be rotting, have them discarded and replaced with like seeds. You should check to see that any bags with rotten seeds are not too moist. Discard any water which is not absorbed by the vermiculite.

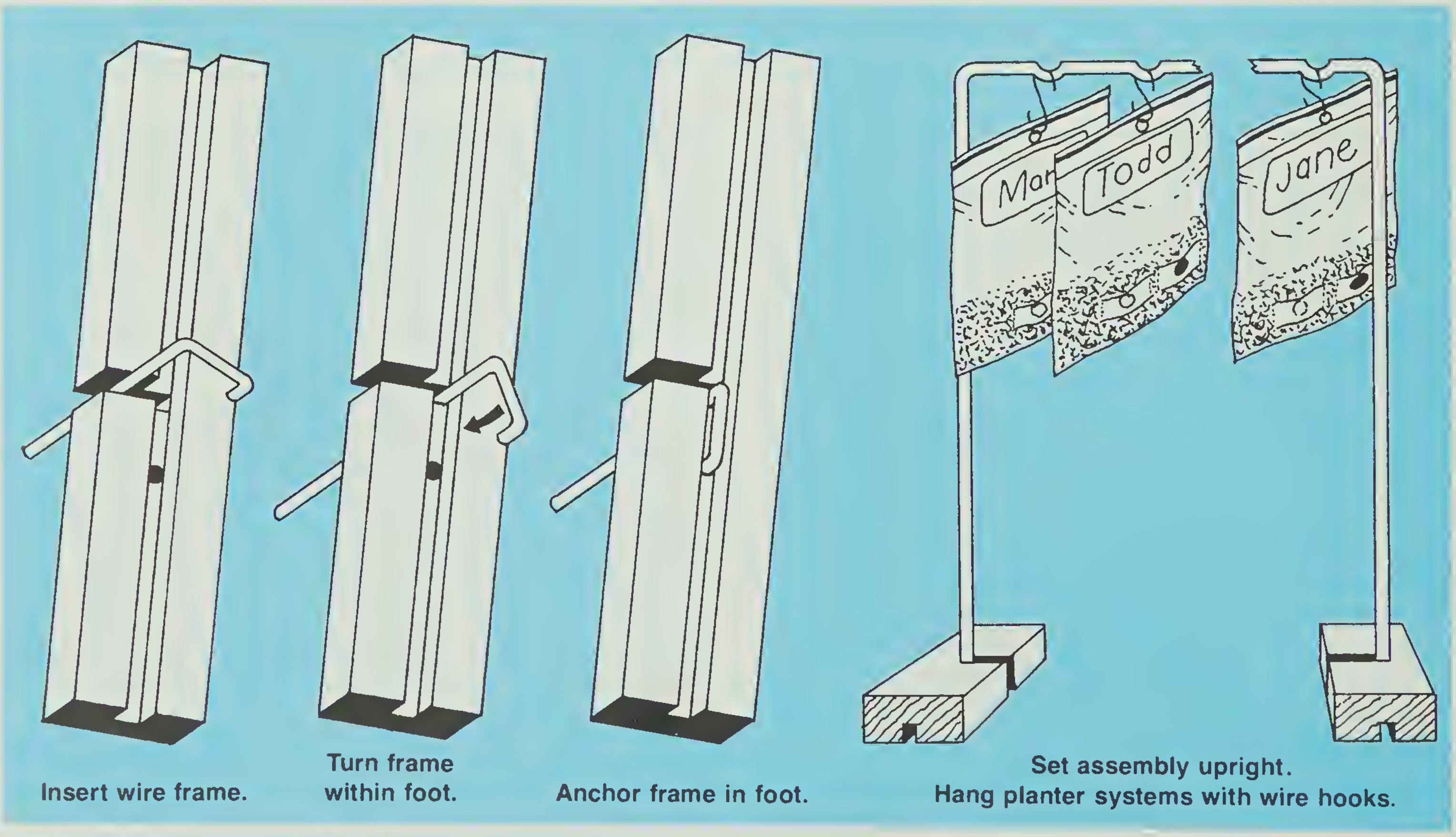
Over the succeeding days, some major changes in the seeds will be noticed by the children. They will speculate about new probabilities while discarding some of their old ideas. Those who didn't think seeds are alive will probably have changed their minds.

"Inventing" development. On the day when the roots emerge from most of the seeds, introduce the concept of development. First be sure that all the children have seen "this new thing" coming out of a seed. Then tell them that when a seed or any other living thing gets a new part, the process is called *development*. The seed is developing new parts or developing into something different. Don't use the phrase "the seed is *growing* a new part" or "*growing* into a plant." *Growth* refers to the enlargement of existing parts and is different from *development*.

Be sure the children "replant" their seeds after examining them, and tell them they will look for more evidence of development over the next few days. Additional water should be added to the vermiculite as needed before the children return their planter systems to the supports.

Over the next few days, encourage the children to refer to the emergence of more roots or plant parts as development. Roots, root hairs, stems, and leaves will soon appear on the developing plant.

Figure 6-3. Assemble and use the support rack as shown.



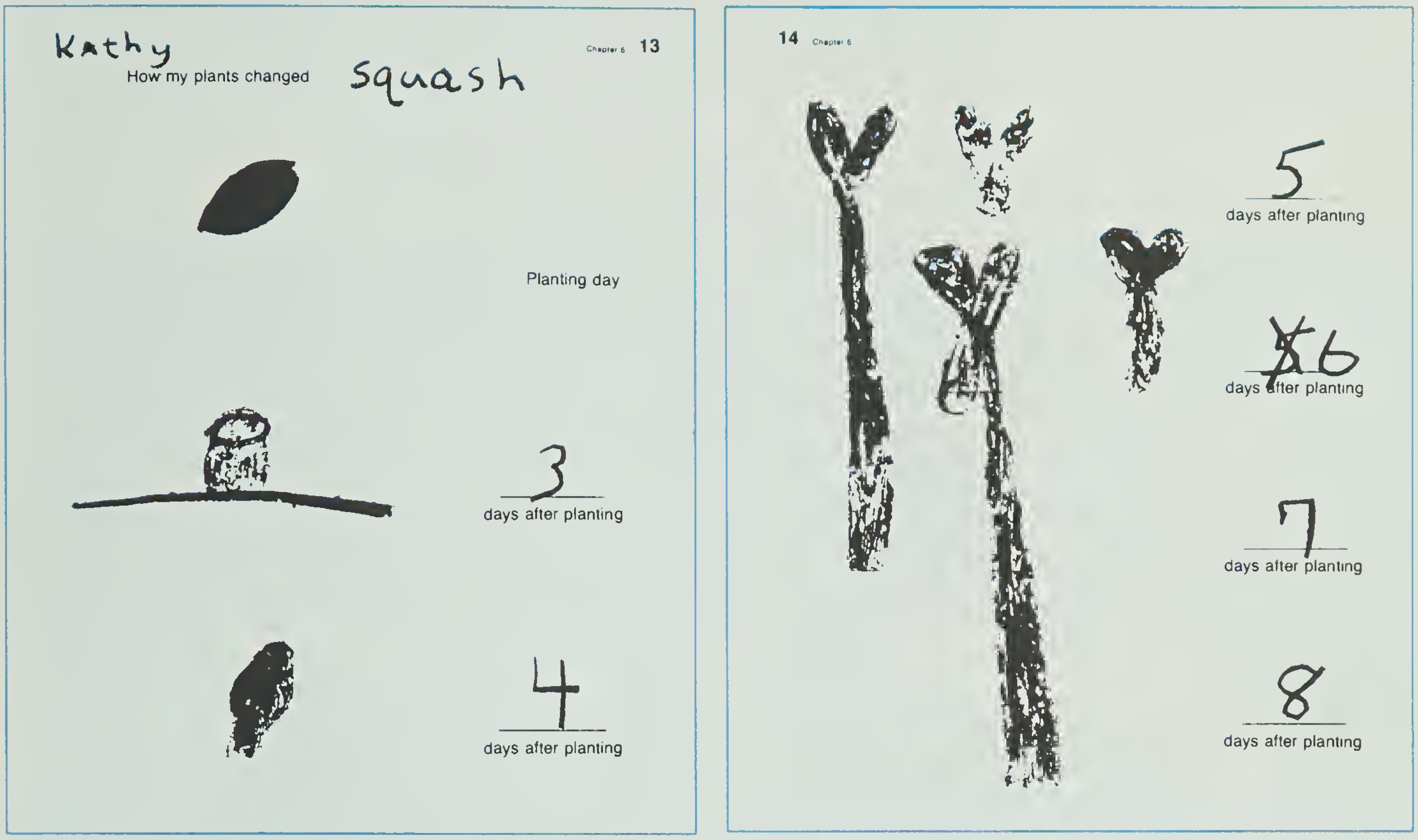
Insert wire frame.

Turn frame within foot.

Anchor frame in foot.

Set assembly upright.
Hang planter systems with wire hooks.

Figure 6-4. A record of squash seed changes after planting.



Chapter 6 13

Kathy

How my plants changed squash

Planting day

3 days after planting

4 days after planting

14 Chapter 6

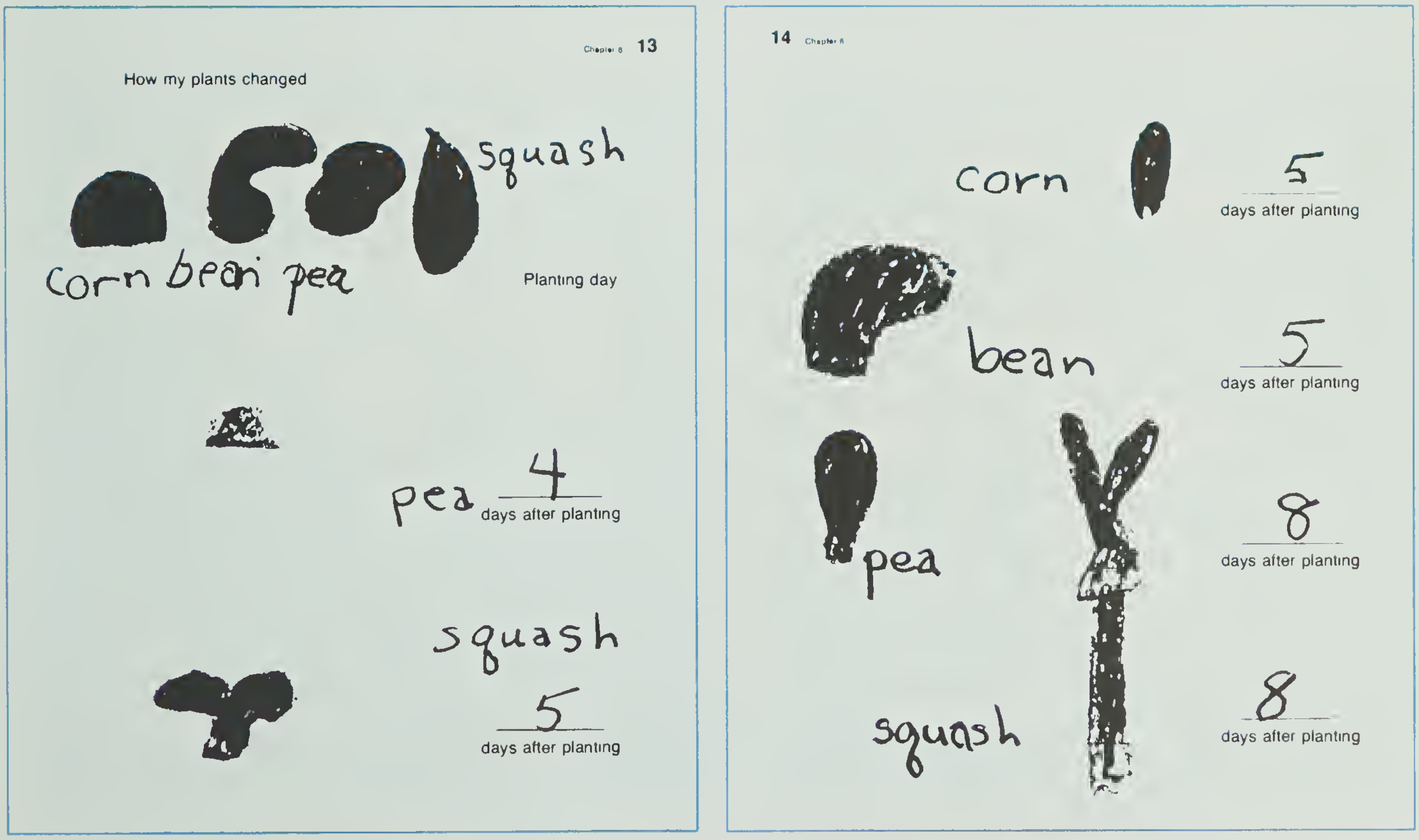
5 days after planting

~~5~~6 days after planting

7 days after planting

8 days after planting

Figure 6-5. An alternate way of using the student manual.



Chapter 6 13

How my plants changed

squash

corn bean pea

Planting day

pea 4 days after planting

squash 5 days after planting

14 Chapter 6

corn 5 days after planting

bean 5 days after planting

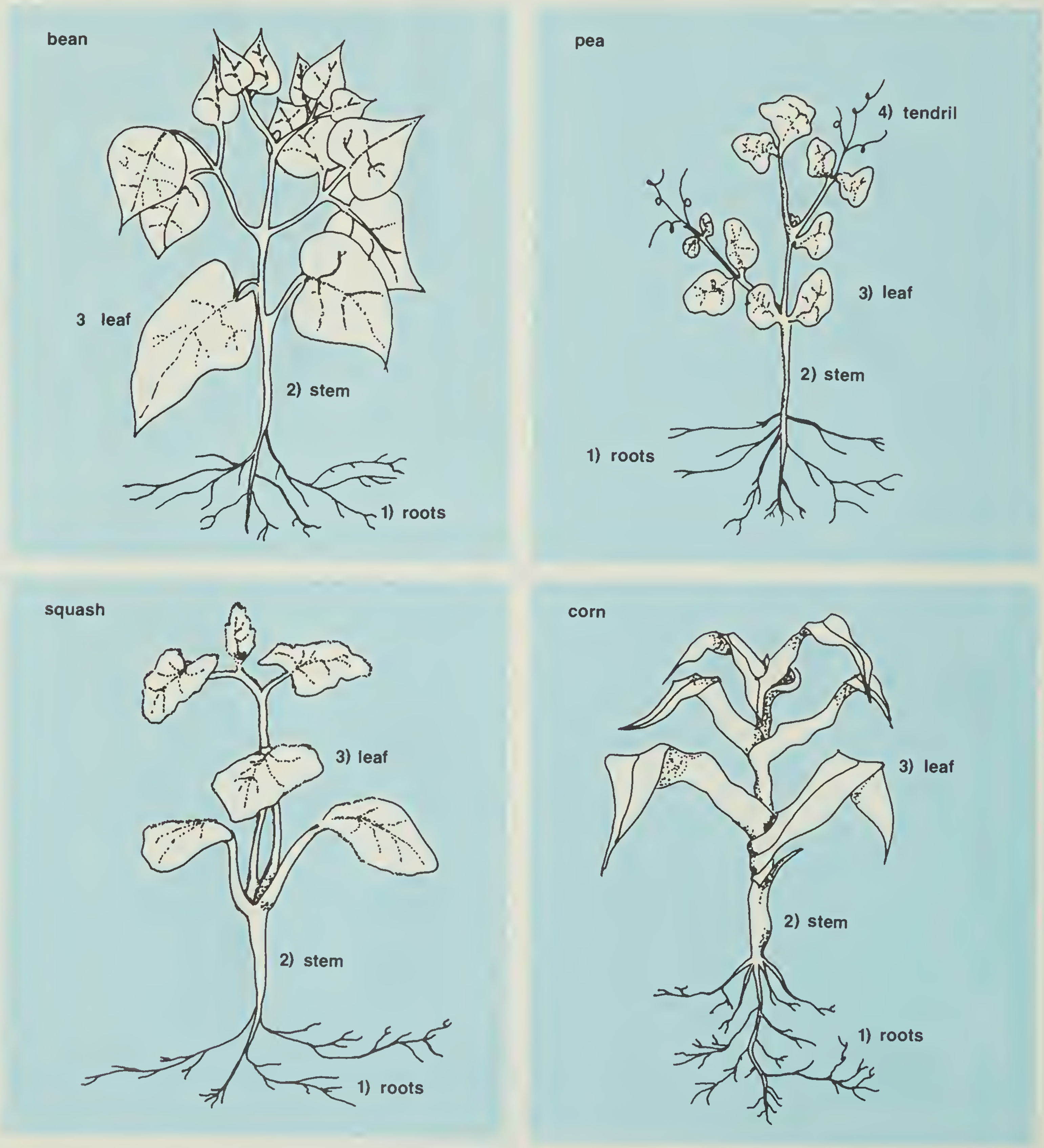
pea 8 days after planting

squash 8 days after planting

Learning names of the major parts. When the children see a new plant part, you can identify it for them if they do not know what it is called. Figure 6-6 will help you. Numbers representing the development sequence are provided beside each labeled plant part.

Adjusting the plant setups. When a plant has grown so much that it threatens to push out of the planter bag, open the zip lock and allow the plant stem to protrude outside the bag (keeping the roots in the vermiculite). Then gently close the zip lock seal around the plant stem, as shown in Figure 6-7.

Figure 6-6. The numbers beside the plant parts indicate the sequence of development.



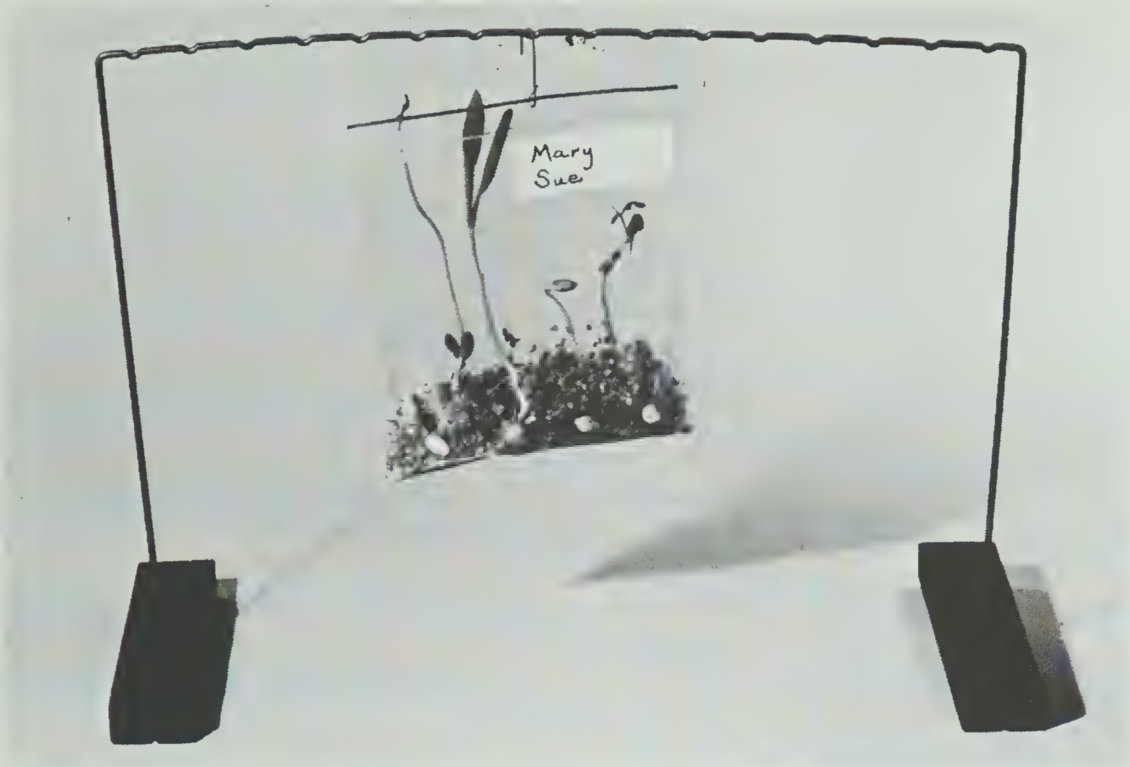


Figure 6-7. Making room for growing plants.

While you wait for the seeds to sprout, proceed with Chapter 7. The two chapters can be carried out over the same period of time.

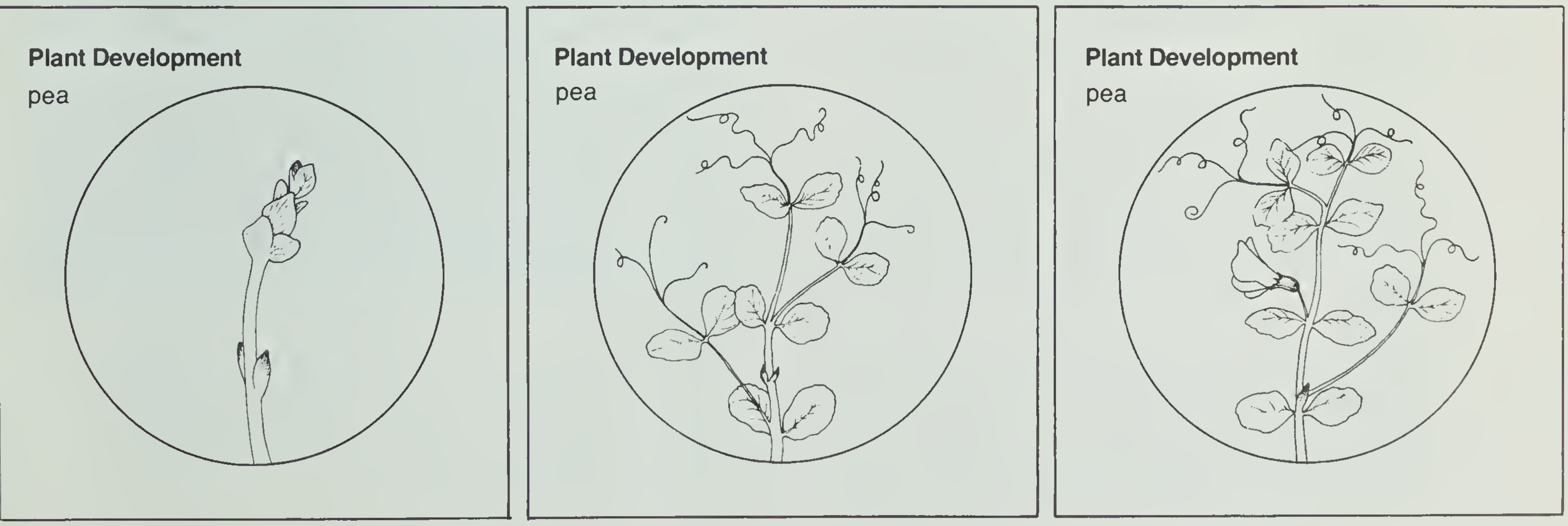
"Inventing" growth. When most of the development has occurred, introduce the term *growth*.

After the children have observed a root or leaf getting larger or longer, tell them the increase in size of a living plant or animal is called *growth*. Let them tell you which parts of their plants are growing. As time goes on, there will be less development and more growth, although flowers will eventually develop.

Over the next few days, give the children many opportunities, through discussion and questions, to practice differentiating between development and growth. All organisms both develop and grow.

Using Development cards. Take the four sets of Plant Development cards from drawer 1. Form four teams having equal numbers and give one deck to each team. Ask each team to place the cards in order, showing the development of that type of plant from the original seed or small plant to a plant bearing flowers or fruit.

Figure 6-8. Correct arrangement of pea development cards.



As each group completes its card sequence, have the children switch card decks with another group until they have sorted all four kinds of plants. The ease with which the children arrange the cards in the correct order will provide you with some insight to their understanding of development and growth, especially if they can identify the difference between growth and development on the card illustrations.

A more challenging use of the cards is to mix up all the Plant cards and see if the children can rank any three they select. This task is more difficult because it prevents them from using size alone as a criterion for ranking the stages.

Transferring the plants to pots. Soon after inventing the growth concept, arrange a time to transfer the healthiest of all the plants to the large flowerpots.

Enlist the assistance of several students to prepare four pots by filling them halfway with soil. Each pot should have a different label—one each for corn, bean, squash, and pea.

By this time, the children are probably concerned because their plants will no longer fit in their planter bags, and so it should not be difficult to get them to transfer their plants to larger containers. From all the class planter bags, let the children select the three best plants of each kind for transfer to a pot.

Show the children how to transfer (transplant) a plant:

- First, thoroughly moisten the soil in the pots. Have additional soil nearby.
- Open a planter bag and gently lift out the plant to be moved.
- Do not try to get the vermiculite off the roots.
- Set the roots on the wet soil in the pot.
- Transplant two or more of the same kind of plant, spacing them somewhat evenly.
- As two children hold the plants upright, a third should add 3–4 cm (2 in) of soil to the pot, covering the roots.
- Immediately water the new (probably dry) soil which was added. It should be well soaked.
- Assign a child or team to check the soil moisture in these pots every other day.

Set the pots on trays, two to a tray, and keep them either under the light source or near the window but out of drafts.

These transplanted plants will be maintained for the children to see what further growth or development will occur.

What to do with the other plants. There is no further use for the remaining plants in the children's planter bags. The children may continue growing the plants in the bags, discard them, or take them home. One trial-classroom teacher suggested transplanting them to a class garden. If the children want to take their plants home, have them transfer the plants and vermiculite to washed milk cartons. Suggest to the children that they add soil to the cartons when they get home.

Observing the growing plants. The schedule of classroom activities for the remainder of this chapter depends on the growth rate of the plants and on the children's comments and questions.

Let the children examine their plants daily, if they wish. They probably will learn most about plant growth and development from informally observing their plants. Your students may particularly benefit from discussing their observations at two times: when flowers appear and when pods (fruit) appear. If you wish, the children may draw pictures of their maturing plants before or after each discussion.

Flowers and fruits. When the children notice flowers on the bean plants, gather them for a discussion. Ask them what they think these newly developed structures are. What do they think will happen to these parts? The children should examine the plants each day. The fruit forms inside a flower and eventually will be visible as a bean pod growing out of the flower. This happens quite rapidly, and the children may miss the process unless they examine the plants daily.

Sequence of plant development. After the bean pods have grown large enough for the seeds to cause a bulge in the pod, have the children open the pods to observe what is inside. They may already know that pods contain seeds because of their experience in Chapter 5. Then give each child a blank sheet of paper and a sheet of eight bean plant pictures. The children are to cut between the pictures and arrange them sequentially. Tell them not to put both seed pictures together. A child should arrange the pictures to his or her satisfaction, then number them 1 through 8 and paste them onto the blank paper.

When the children have finished numbering and pasting their pictures, ask them to put their names on them. Collect and save the pasted-up pictures until you are ready to invent the concept of life cycles in Chapter 13.

Cleanup. Rinse and air dry the plastic bags for future use.

OPTIONAL ACTIVITY

Planting peas. Obtain and plant three different kinds of peas (or other plant, such as corn, bean, or lettuce) using the techniques in this chapter. Record the development and growth of the three types until they each produce seeds. Observe the differences in the life cycles of the three varieties.

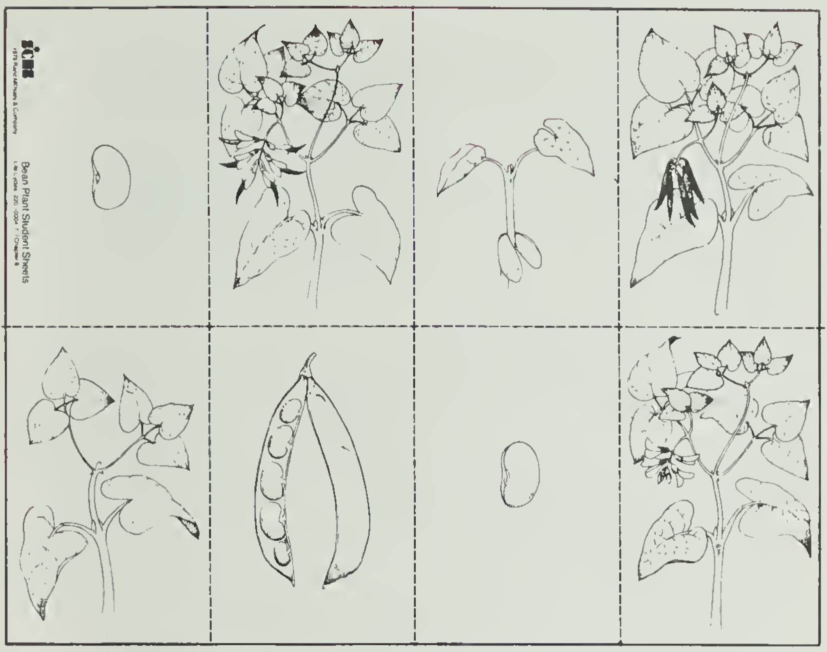
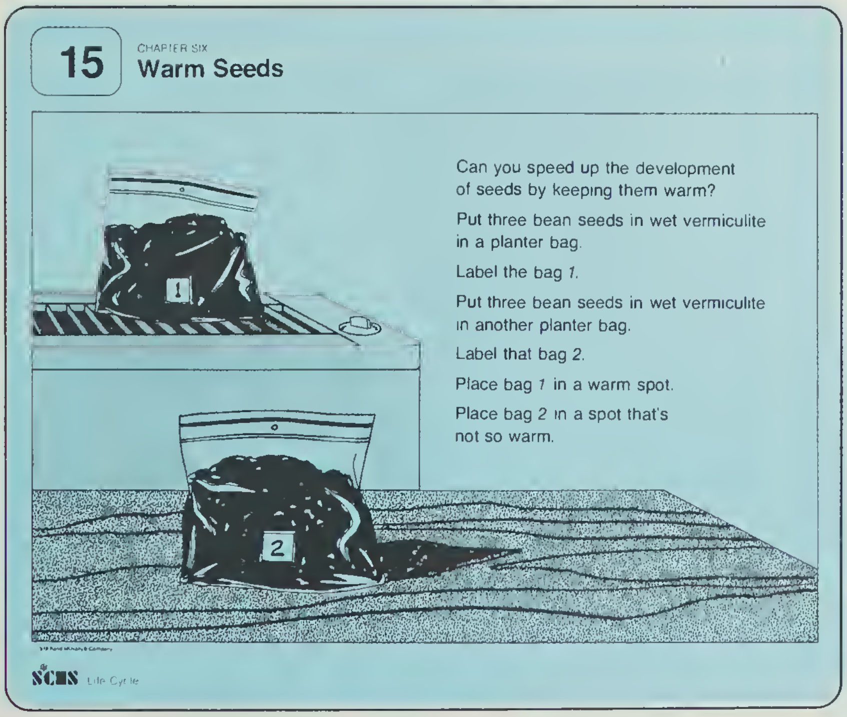


Figure 6-9. Bean Plant student sheet.

EXTENDING YOUR EXPERIENCE CARDS

15. Warm Seeds. The child will need two plastic zip lock bags, some vermiculite, a water sprinkler, and six bean seeds. Help the student select two appropriate areas—one about 20°C (68°F), the other warmer by at least 3 degrees C (5 degrees F), but not hot. The bags should receive equal amounts of light.



15

CHAPTER SIX

Warm Seeds

Can you speed up the development of seeds by keeping them warm?

Put three bean seeds in wet vermiculite in a planter bag.

Label the bag *1*.

Put three bean seeds in wet vermiculite in another planter bag.

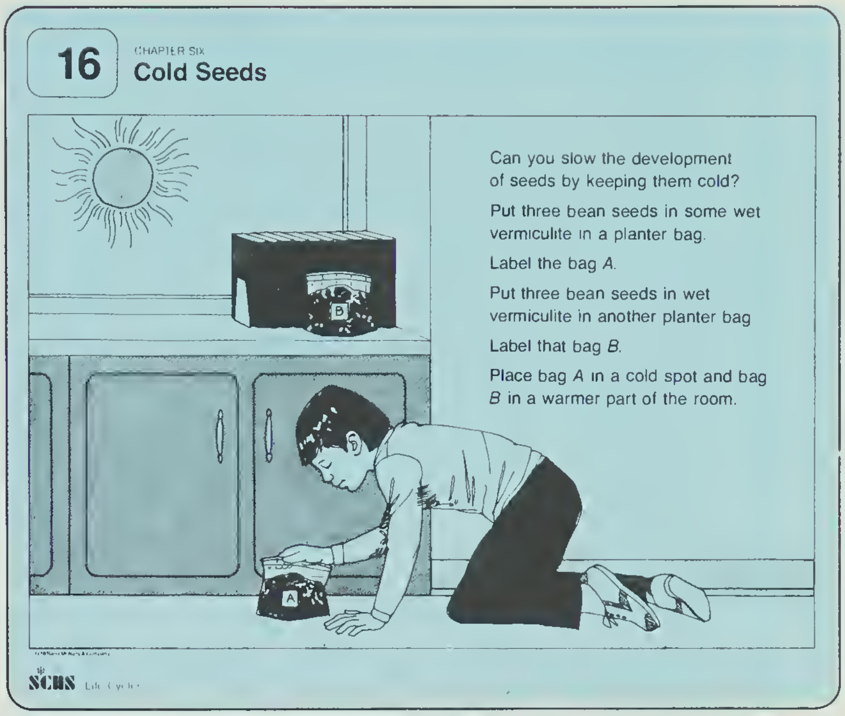
Label that bag *2*.

Place bag *1* in a warm spot.

Place bag *2* in a spot that's not so warm.

SCIIS Life Cycle

16. Cold Seeds. The child will need the same materials as for "Warm Seeds." One area should be about 20°C, the other at least 3 degrees C cooler—but not freezing. Again, the bags should be lighted equally.



16

CHAPTER SIX

Cold Seeds

Can you slow the development of seeds by keeping them cold?

Put three bean seeds in some wet vermiculite in a planter bag.

Label the bag *A*.

Put three bean seeds in wet vermiculite in another planter bag.

Label that bag *B*.

Place bag *A* in a cold spot and bag *B* in a warmer part of the room.

SCIIS Life Cycle

GETTING READY

To prepare for Chapter 8, find an area near the school that has a wide variety of seeds. These seeds may be either on a plant (but ripe) or on the ground. Often the fallen seeds have rolled into a shallow spot, or they have been swept by wind and passing cars into gutters, inside corners of buildings, or under porches and are not easily found in the open lawn or field. An area which has at least seven different kinds of seeds is best. Select some obvious boundaries for the children while you are checking out the site.

About three weeks before you expect to begin Chapter 9, send in the order form for Live Organism shipment LC-1.

Note. Frog eggs, contained in shipment LC-1, can be shipped only between November 1 and April 1. Be sure to consider this in planning the rest of this unit.

7 Experiments with Plants

SYNOPSIS

Children experiment with seeds and plants to find answers to questions raised during previous chapters.

Suggested time: ***one session to set up, followed by about ten days of observation***

TEACHING MATERIALS

For each child:

student manual pages 15 and 16

For the class:

soil‡
vermiculite‡
cups, vials, or cutoff milk cartons*
list of questions (from Chapter 4)

Drawer 2

1 light source

Drawer 3

16 small plastic zip lock bags

Drawer 4

2 large fluted containers

Drawer 5

seeds (bean, corn, pea, squash, and radish)
16 planter cups
16 planter bases
6 water sprinklers

* provided by the teacher
‡ Sand and Soil box

ADVANCE PREPARATION

You should have sprouted some bean and corn seeds, as directed on page 20, about a week ago.

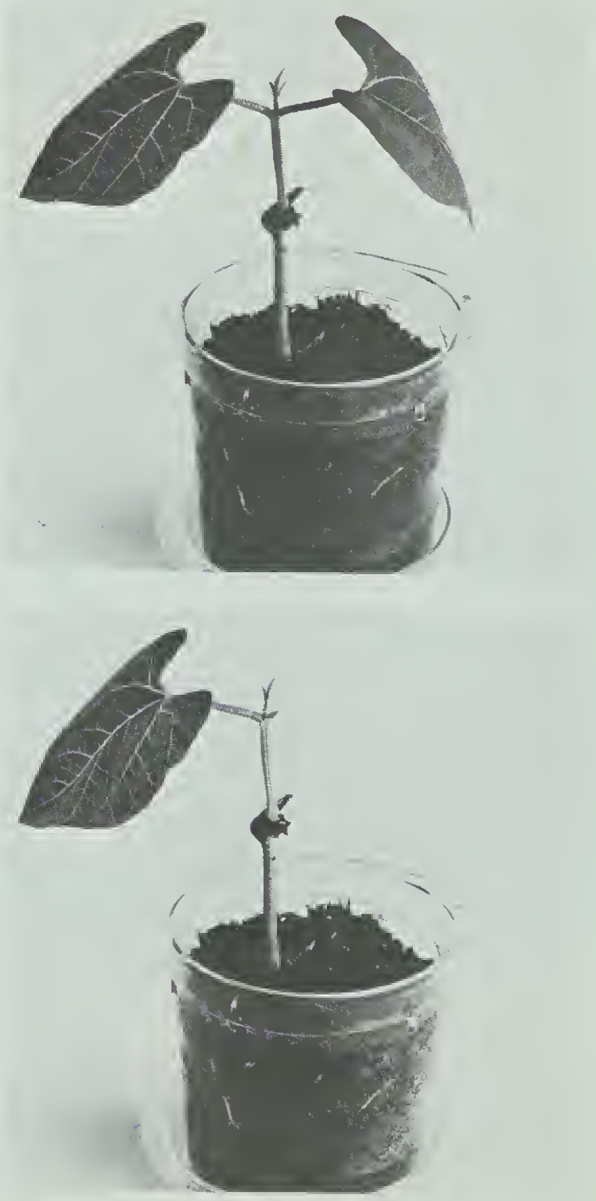
At this time, set up at least three distribution stations where the children can pick up seedlings, planter cups, planter bags, soil, and water sprinklers.

TEACHING SUGGESTIONS

This activity forms the discovery phase for *growth* and *development*.

Planning experiments. In Chapter 4, you prepared a chart paper list of the children's questions about seeds. In succeeding chapters, other questions have probably arisen—about some plants growing faster, slower, taller, greener, without one or both leaves, without water, with milk, and so forth.

Figure 7-1. Does breaking off a leaf hurt the bean plant?



Show the children the chart paper list, remind them of questions they have asked, and tell them they can find the answers to many of these questions themselves.

Assign the children to teams of two. Have each team begin by agreeing on one question that can be answered by experimenting and observing the results.

Tell the children that three corn and three bean plants, plus whatever other extra seeds and plants can be spared, are available to each team when they are ready. Knowing what they have to work with, the children can now plan their experiments. They can pick up whatever seeds, plants, and other materials they need at the distribution stations you have prepared.

Some examples of questions and experiments that will answer them follow.

"Does breaking off a leaf hurt the bean plant?"

In each of two planter cups containing soil, plant a bean plant that is 5–20 cm high. Break off a leaf from one plant, as in Figure 7-1. Place the cups side by side and see if one plant grows better than the other. Allow about ten days.

"Do roots always grow down?"

"Plant" two of the same kind of seeds in a plastic zip lock bag nearly full of moist vermiculite. When the roots develop, see which way they are growing. Then turn the bag upside down, as in Figure 7-2, and see if the roots continue to grow in the same direction. Allow about five days for any results to become noticeable.

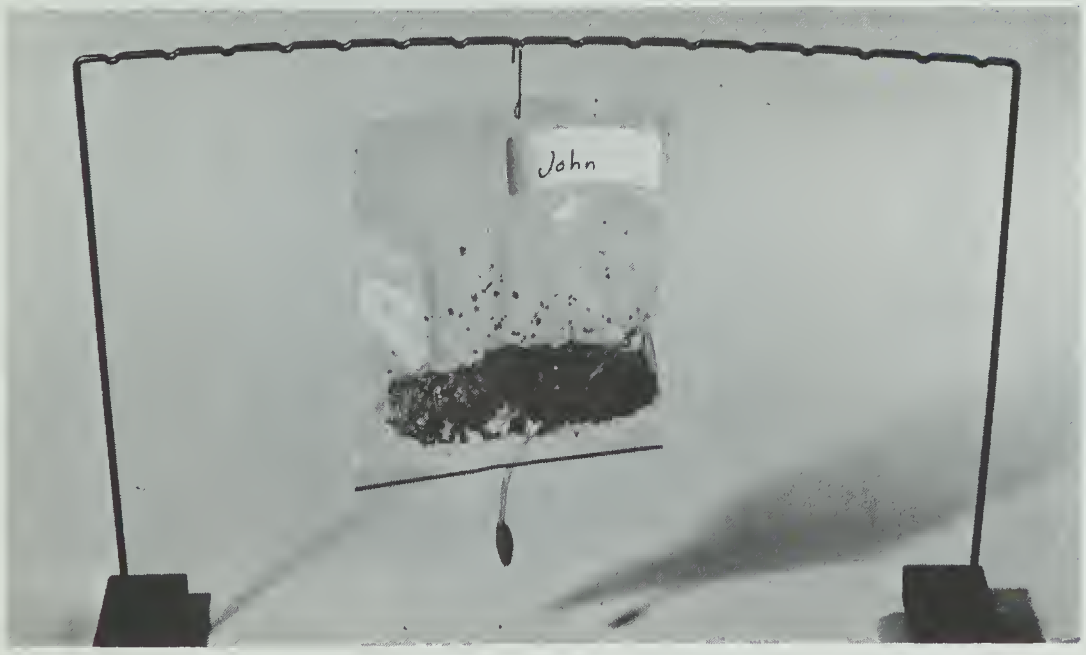


Figure 7-3. Will a plant grow when turned upside down?

"Will a plant grow upside down?"

"Plant" two plants of the same kind in two zip lock bags so the roots are in the bags and the stems extend outside. Be sure there is some moist vermiculite for the roots inside the bags. Seal the bags as well as you can around the stems. Turn one bag and plant system upside down and keep the two plants close together. Compare their growth. Allow six to ten days for results.

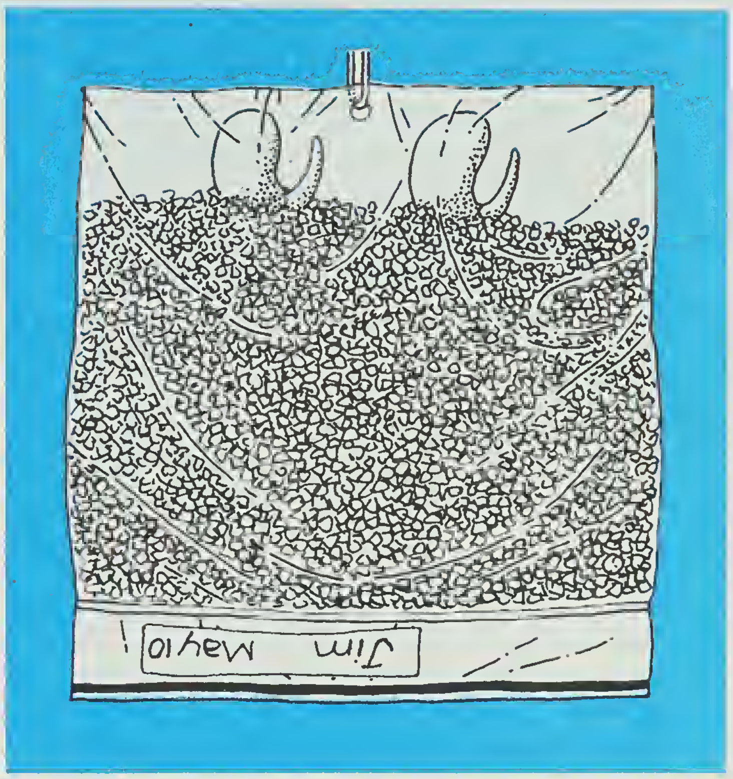


Figure 7-2. Do roots always grow down?

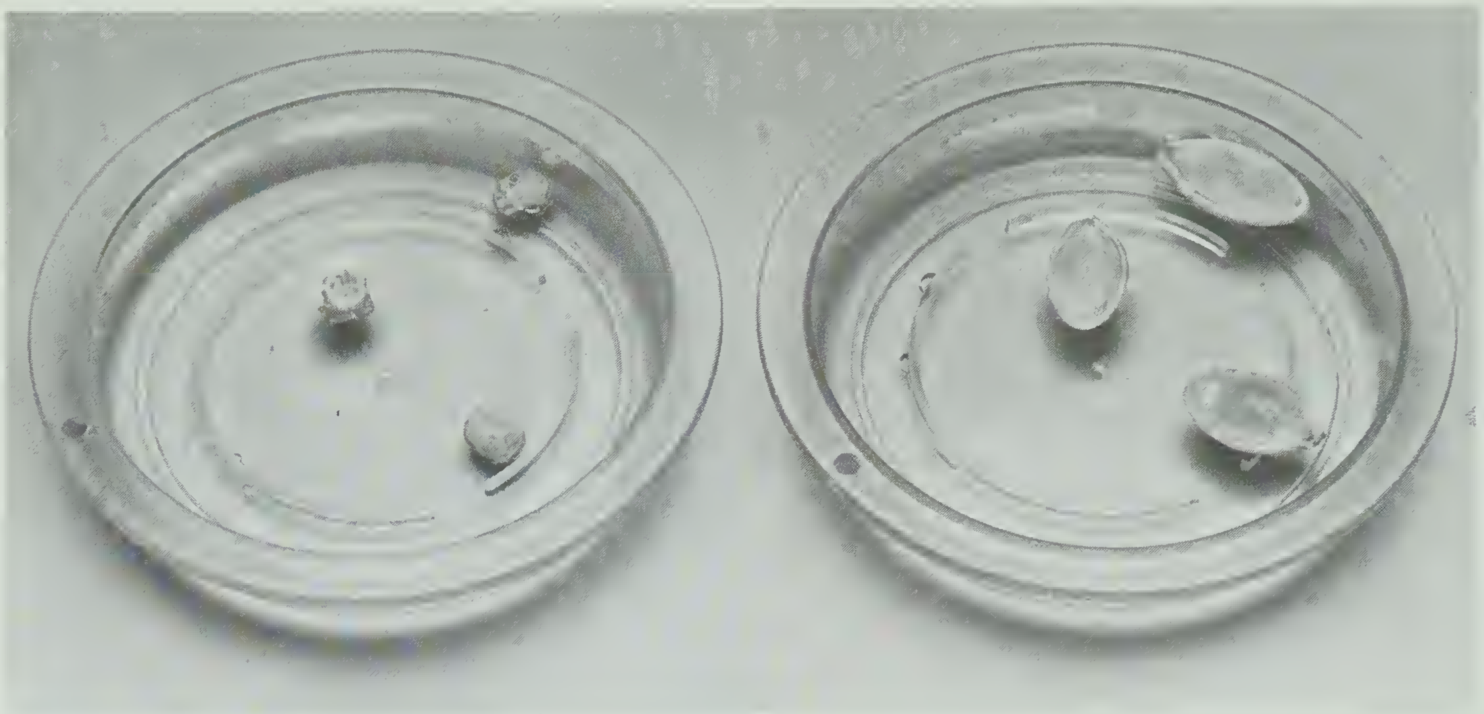


Figure 7-4. Do seeds drown in water?

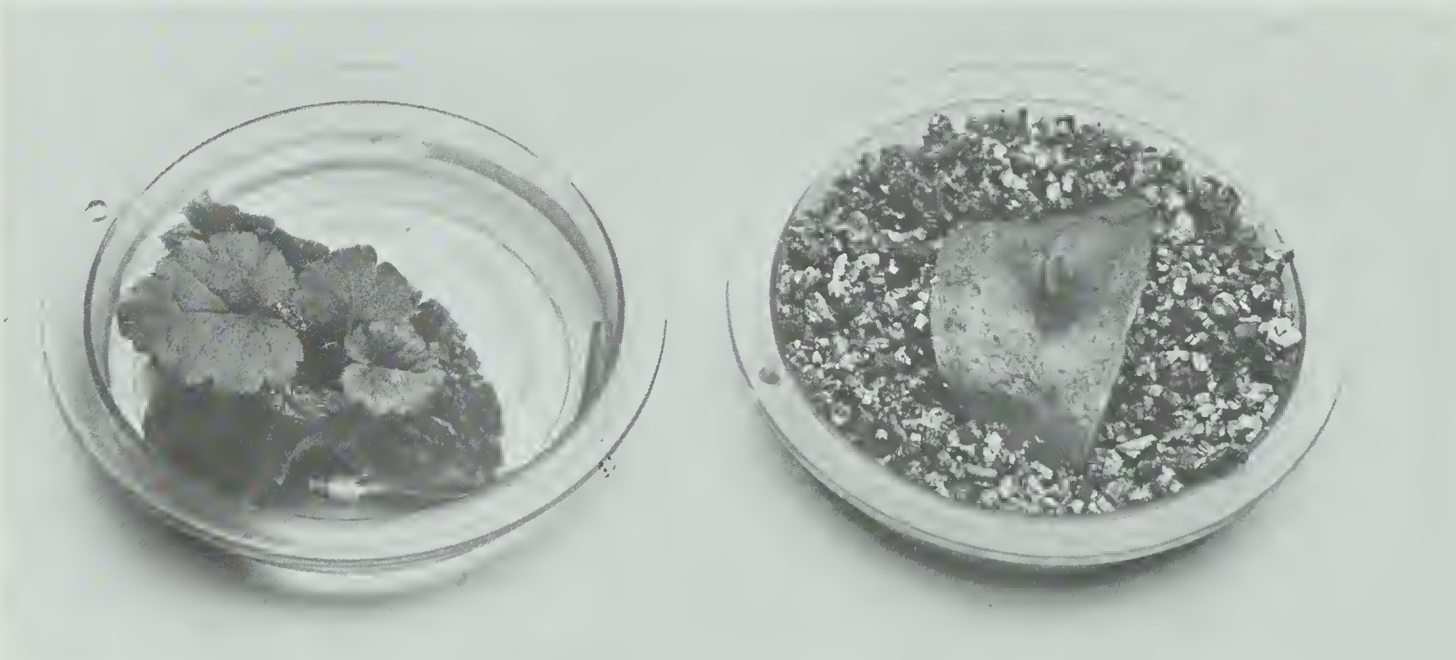
"Do seeds drown in water?"

Put three of each kind of seed available in a separate planter cup base and fill the bases with water, as in Figure 7-4. Some seed types may rot, but other types (usually the smaller ones) may develop normally. Allow four to ten days for results.

"Are seeds the only way you can get new plants?"

This question probably can't be answered without your suggesting that the child test white potato eyes, African violet leaves, ivy or willow branches, or geranium or piggyback plant cuttings. Place any of these plant parts in a cup or vial of water (Figure 7-5). (If you use a potato section, set it on moist vermiculite.) Allow five to fifteen days for new features to develop. Store experiments involving green plants near the light source. Seeds will germinate in the dark.

Figure 7-5. Will these plant parts develop into new plants?



Using student manual pages 15 and 16. Either before setting up the experiment or shortly afterward, the children can record what they intend to find out and draw or describe their experiment. When the results are known, they can state them at the bottom of page 16.

Many other such experiments may be conducted by the children to find out answers to their questions. In most cases, these experiments need two parts: one plant to be grown in a way (such as upside down) that will answer the question and a similar plant grown in normal fashion. Figure 7-6 shows one such experiment.

The second plant is used as a comparison to the plant being tested and should be kept in exactly the same conditions as the plant being tested—the same amount of light, warmth, breeze, etc. This second plant is called a *control.* You may or may not want to explain that to the children. The concept is not easy for them to understand at this age and trying to explain it requires a good deal of effort on your part.

Reporting the results. Whenever an experiment is completed, the child or team should both tell and show the others the results of their experiments. A

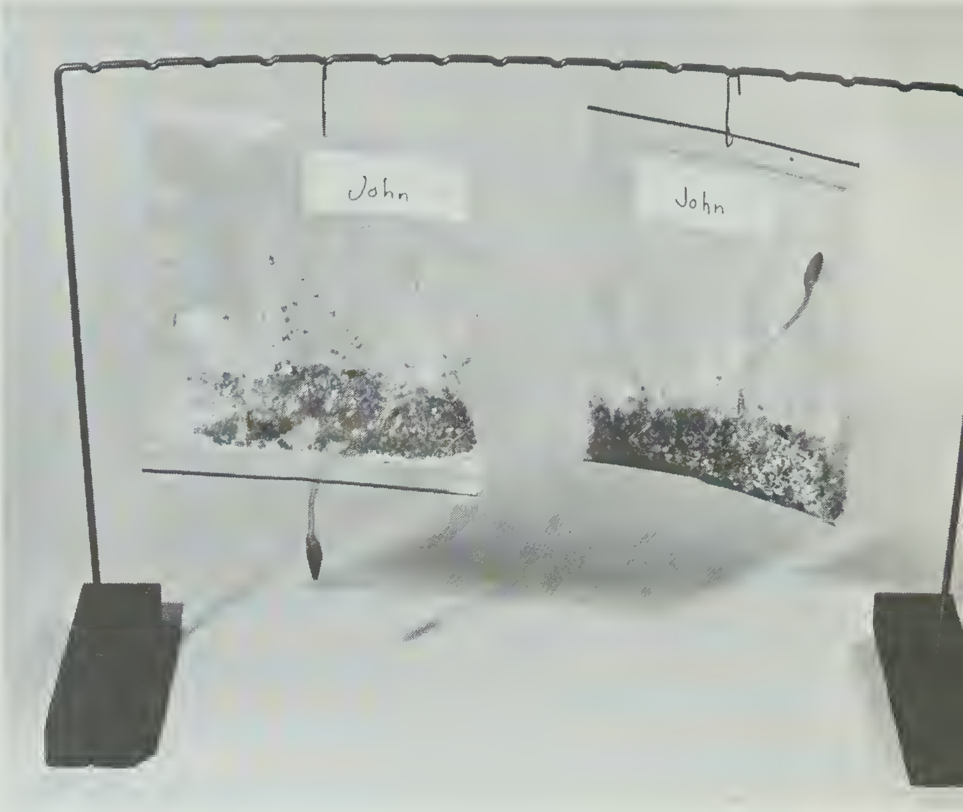
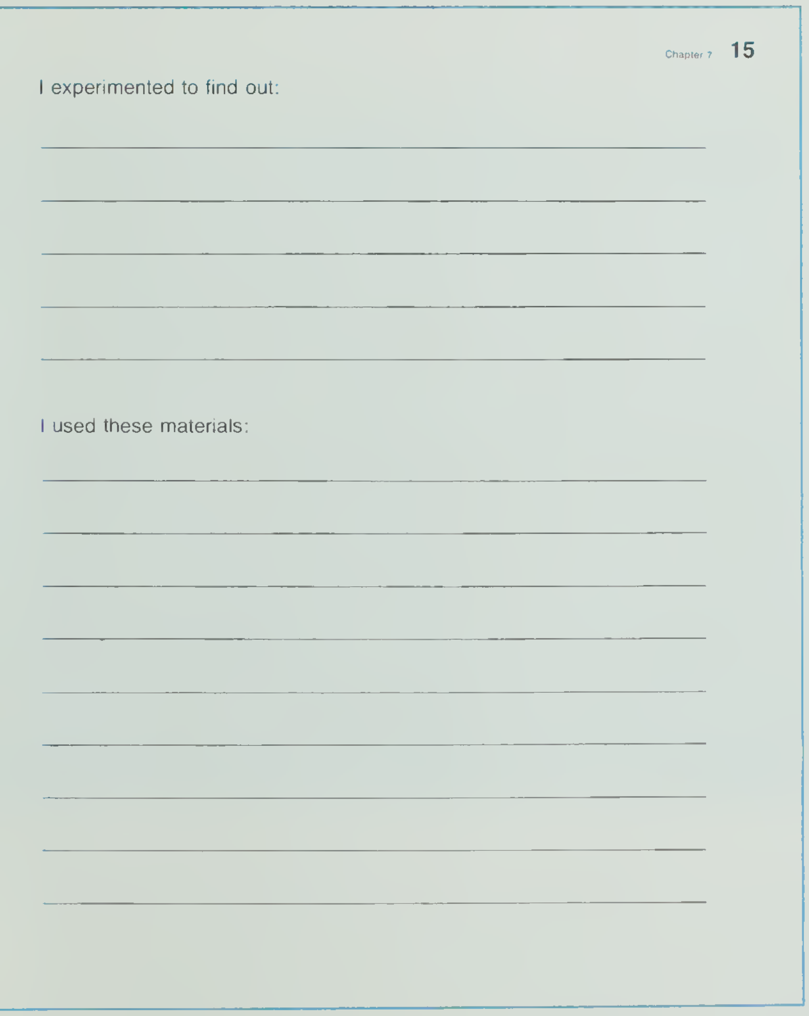


Figure 7-6. A controlled experiment to see if an upside-down plant will grow.


Chapter 7 15

I experimented to find out:

I used these materials:

16 Chapter 7

My experiment looked like this:

I found out that:

pattern of reporting is usually helpful. Encourage the reporting team to tell the others:

1. The original question.
2. What they did.
3. What happened to their seeds or plants.
4. What they decided.

Experiments to answer the children's questions should be used to answer other such questions throughout this and other SCIIS units. You can't find answers to many of the children's questions by looking in encyclopedias or reference books. But doing simple experiments can frequently provide reliable answers more rapidly and easily than looking up the answers or arranging for an expert to visit. More importantly, experimenting is a significant lifelong process for all persons, not just for scientists. The girl or boy who finds out answers independently when possible has learned a valuable lesson.

Discovery events. As the children become more familiar with the changes in plants while experimenting with development and growth, they will make additional discoveries: "Look! The bean seed is stuck on the stem!" or "When I cut the corn it just grows again but the bean stops growing." These experiences provide opportunities for the children to enhance their understanding of development and growth and to correctly differentiate between the two concepts.

Planning ahead. The Chapter 8 field trip can be taken while you wait for results, on any day when the weather allows going outdoors.

Cleanup. After an experiment is concluded, it should be cleaned up. Plants may be taken home in milk cartons or discarded. Vermiculite should be dried and saved. Cups, containers, and bags should be rinsed in water only, dried, and returned to the kit. You may find it helpful to soak the cups and containers for a day or two and to use a brush for removing soil.

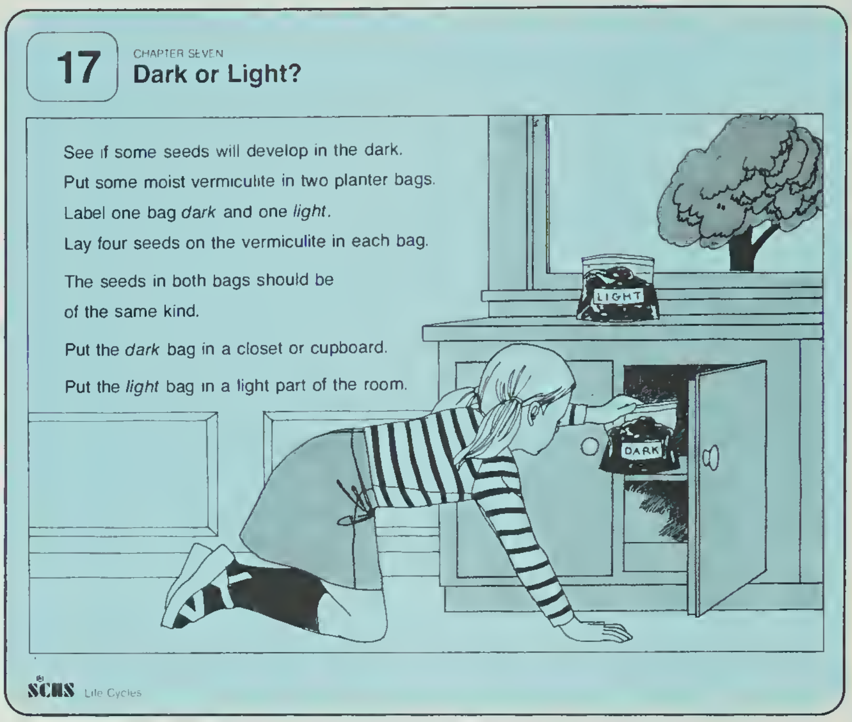
OPTIONAL ACTIVITY

A plant race. Students may wish to try their hands at selecting superior seeds, providing perfect conditions, and having a growing contest to see who can grow the biggest and best plants in the shortest time.

A discussion about everyone using the same size containers, such as milk cartons, is probably necessary. Outside of that constraint (which will eliminate helpful fathers bringing in redwood tubs), you might let anything else go. The children will learn much about plants and have fun, too.

EXTENDING YOUR EXPERIENCE CARDS

17. Dark or Light? Be sure that the children use the same kind of seed in each bag. The results of this activity may surprise both you and the children.



17

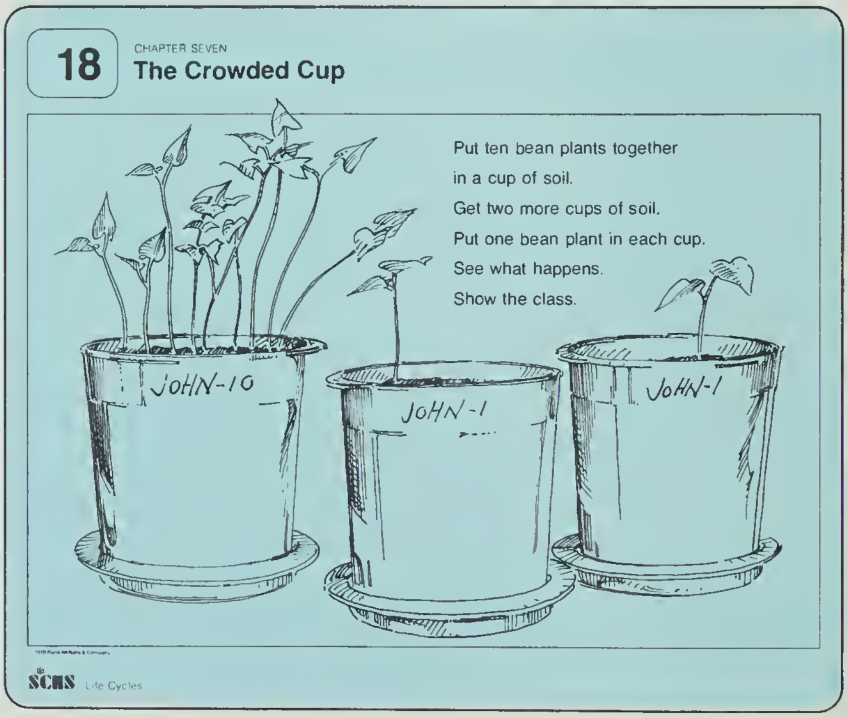
CHAPTER SEVEN

Dark or Light?

See if some seeds will develop in the dark.
Put some moist vermiculite in two planter bags.
Label one bag *dark* and one *light*.
Lay four seeds on the vermiculite in each bag.
The seeds in both bags should be
of the same kind.
Put the *dark* bag in a closet or cupboard.
Put the *light* bag in a light part of the room.

SCIIS Life Cycles

18. The Crowded Cup. Provide cups, soil, and labels. The children may discover that beans do not suffer from crowding.



18

CHAPTER SEVEN

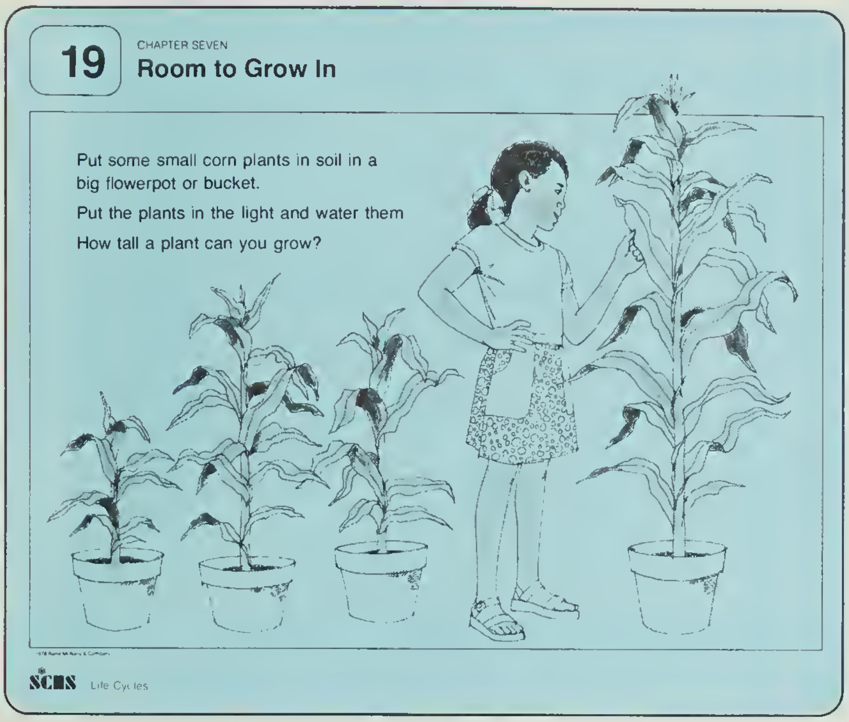
The Crowded Cup

Put ten bean plants together
in a cup of soil.
Get two more cups of soil.
Put one bean plant in each cup.
See what happens.
Show the class.

JOHN-10
JOHN-1
JOHN-1

SCIIS Life Cycles

19. Room to Grow In. Locate a bucket, large planter, or cardboard box carefully lined with heavy plastic. The corn plants may need support sticks.



19

CHAPTER SEVEN

Room to Grow In

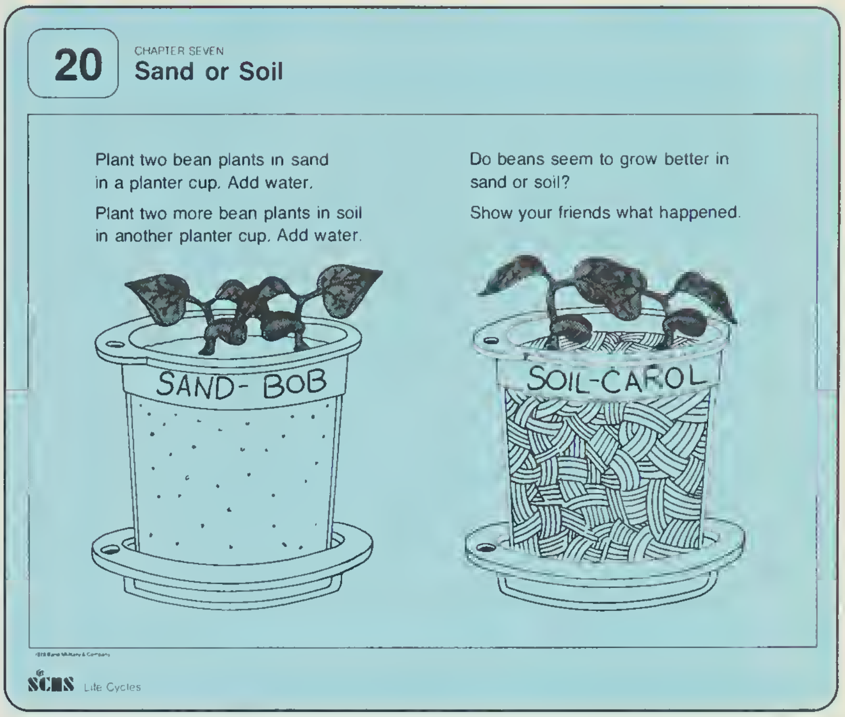
Put some small corn plants in soil in a big flowerpot or bucket.

Put the plants in the light and water them

How tall a plant can you grow?

SCIS Life Cycles

20. Sand and Soil. Pebbles, aquarium sand, or even beach sand may be used. Four plants and planters are needed.



20

CHAPTER SEVEN

Sand or Soil

Plant two bean plants in sand in a planter cup. Add water.

Plant two more bean plants in soil in another planter cup. Add water.

Do beans seem to grow better in sand or soil?

Show your friends what happened.

SCIS Life Cycles

8 The Great Seed Hunt

SYNOPSIS

Children collect seeds in the school area and experiment to see if they are alive. Children find out whether all seeds of one kind produce the same kind of plant.

Suggested time: *one session for the field trip, then a classroom session one week later*

TEACHING MATERIALS

For each child:

student manual page 17

For each team of four children:

1 pencil*
4–6 pieces of paper (11 x 14 cm or "half sheets")*

Drawer 2

1 tray

Drawer 3

2 plastic bags

Drawer 5

2 planter cups and bases

For the class:

soil‡
transparent tape*

Drawer 2

1 light source

Drawer 4

3–5 tumblers

* provided by the teacher
‡ in Sand and Soil box

ADVANCE PREPARATION

If you have not yet determined where to take the children for this field trip, do so now. Use the suggestions on page 35. You will need some milk cartons for extra setups or smaller teams.

TEACHING SUGGESTIONS

This activity is a further opportunity for discovery of seed characteristics. In addition, exploration of seeds leads to invention of the concept *genetic identity*.

Collecting seeds. Tell the children they will go on a field trip to search for all kinds of seeds. Some of each kind of seed will be collected and brought back to the room for observation. Assign the children to teams of two.

On the way out the door, have each child get a plastic sandwich bag to use for carrying seeds. When you reach the area to be searched, point out the boundaries, then search with the children. When most of the teams have collected three or more of each kind of seed they can find, return to the room and sort the seeds.

Figure 8-1. Searching for seeds in a small area.

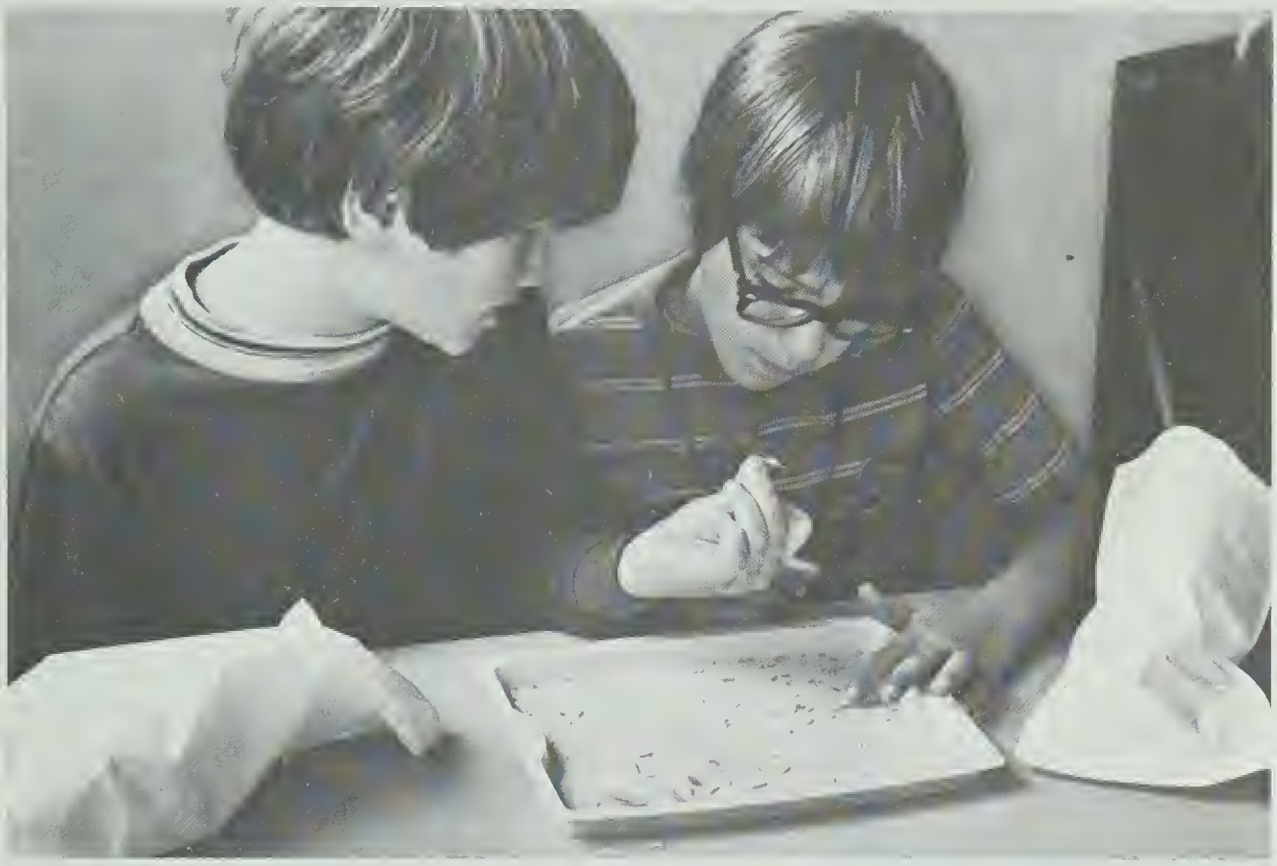


Figure 8-2. Grouping seeds on a tray.

Have one student from each team of two get a tray from the distribution station for use as a team sorting container. Encourage the children to group similar seeds in separate areas of the tray. Once this has been done, ask the children if they think the seeds they collected are alive or dead. If there is not total agreement, ask them how they could find out. At this point in the unit, you should expect someone to suggest planting them to find out. Before you have the children plant, however, pick up two of the same kind of seeds from two different teams. Display them and tell the students you have two seeds which look exactly alike. Ask the children if they think the two seeds will become the same kind or different kinds of plants.

Genetic identity, or "like produces like." Some children, because of their limited experiences with plants, do not realize that apple seeds always produce apples and never develop into pears, corn or soybeans. This is because of the *genetic identity* of the apple seeds—the seeds possess the same genetic material or messages for how to develop and grow. All seeds with the same genetic identity will develop and grow into the same kind of plants. While the term *genetic identity* is useful for adults, in working with children you will probably want to express the concept as "like produces like."

If any of the children think one kind of seed can develop into any type of plant, this is an opportunity for them to find out whether it can for themselves, by matching each kind of plant with the kind of seed from which it came.

Experimenting. The children are now trying to find answers to two questions: (1) Are the seeds alive or dead? and (2) Does the same kind of seed always produce the same kind of plant? Write the questions on the chalkboard.

Encourage the children to plan an experiment to answer these two questions. A single planter for each child will probably provide enough growing area unless many different kinds of seeds have been collected. In that case, children can work in teams of two, planting half the seed kinds in one cup and half in another.

During the planning, you might ask the children how they will remember what kind of seed they planted after the plant has developed. If they don't suggest taping a seed on the outside of the cup next to the same kind of seed planted on the inside, as was done with the zip lock bags in Chapter 6, you should do so.

As the children prepare the planter cups and plant the seeds, walk among them to see if they have any questions.

Allow a little over a week for this mixed batch of seeds to emerge as plants. There will be seeds which do not develop because of previous abuse, age, contamination with winter road salt, and so on.

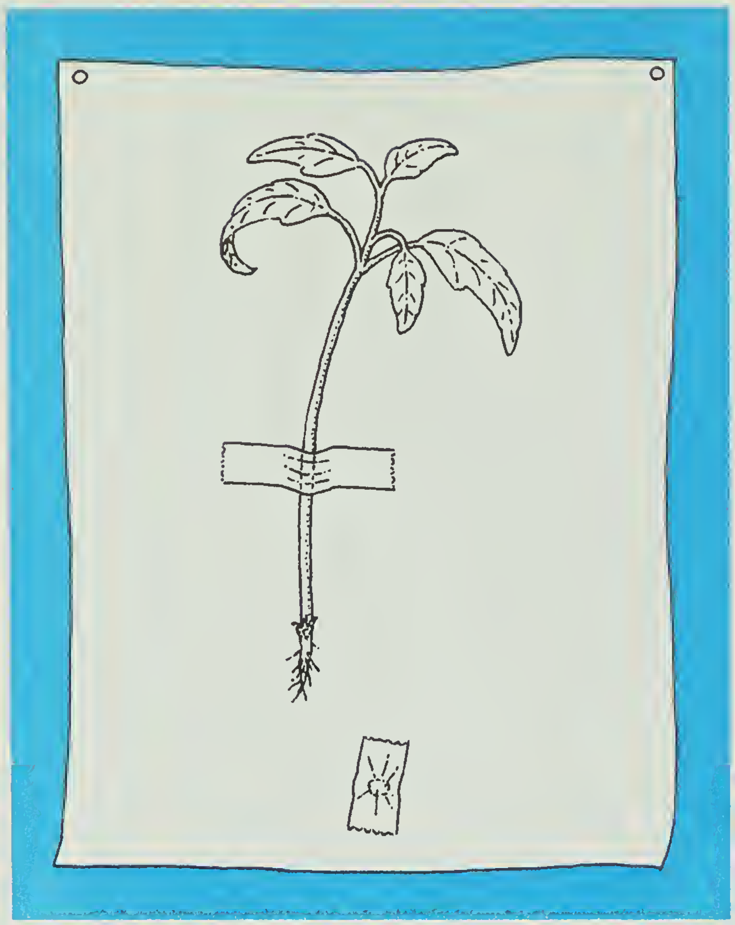
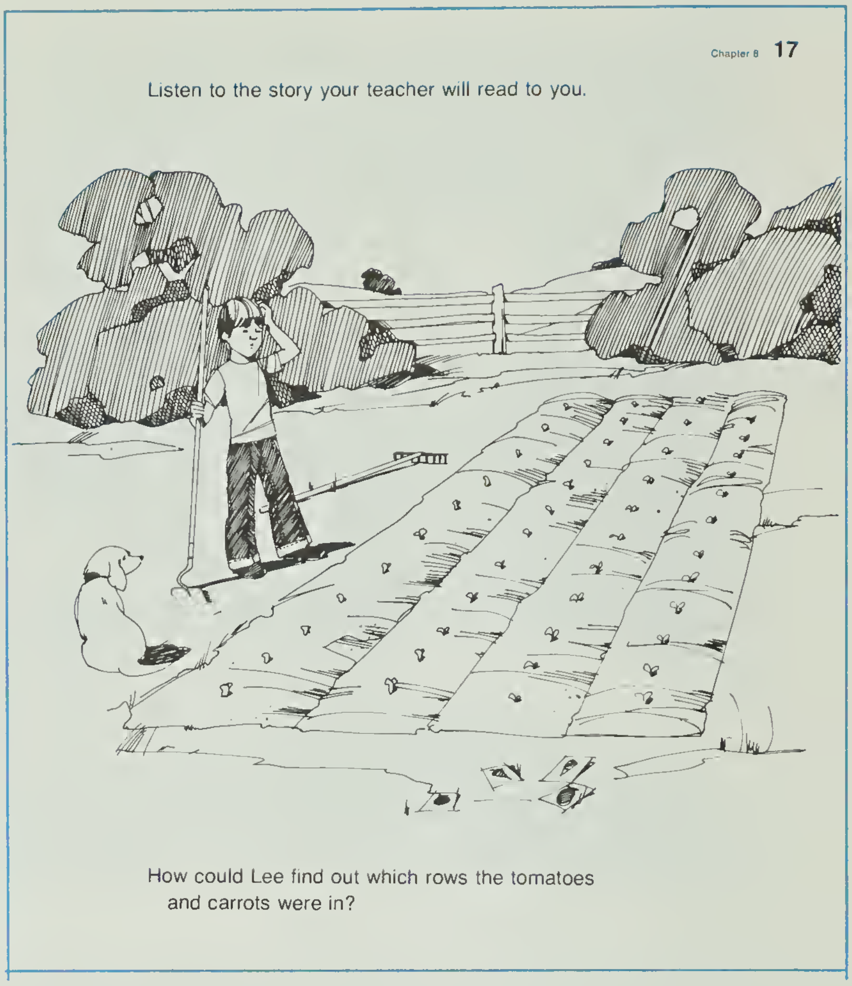


Figure 8-3. Displaying the evidence.



Chapter 8 17

Listen to the story your teacher will read to you.

How could Lee find out which rows the tomatoes and carrots were in?

Results. When many of the seeds have developed, have the children bring their plants and sit down to discuss the results. Remind the children of the first question, "Are these seeds alive or dead?" and ask them what they found out. There may be some kinds of seeds which never developed at all, some which developed but died, and many which are living well.

The second question, "Does the same kind of seed always produce the same kind of plant?" can also be answered now. One way to display the evidence is to have each team tape both the seed from the outside of the planter cup and the matching plant to a small sheet of paper. If no plant developed, the seed should be taped onto a paper anyway (Figure 8-3). When these have been prepared, seat everyone on the floor and have the children sort all the papers according to the kind of seed. These papers will now tell the class which seeds were found most frequently, which developed and which did not, and whether the same kind of seed always produces the same kind of plant.

Using student manual page 17. Tell the children the Lin and Lee story while they are looking at the picture in their student manuals. The youngsters can record their answers, or they can look at the illustration as you lead a discussion about Lee's problem and how it could be solved.

Lin and Lee story. Lin's mother told her to plant some seeds in the backyard so the family could have some squash, carrots, beans, lettuce, and tomatoes to eat in the summer.

Lin planted some of the packaged seeds in rows and watered the whole garden every day. When she went to camp, she asked Lee to take care of the garden. She told Lee that the young plants were growing fast, and soon they would be too crowded. Lee would have to pull up every other tomato and carrot plant to make room for the remaining plants. But Lee's puppy pulled up all the sticks that were used for labels! Lin knew which row was which, but she was away. How could Lee find out which plants were tomatoes and which were carrots?

OPTIONAL ACTIVITY

One seed, one plant—or less. Probably some of the children's seeds did not develop into plants. This activity demonstrates that not all seeds develop into plants or that seeds don't all develop at the same time. It will also reinforce the genetic identity concept—that any one kind of seed produces only one kind of plant and that plants from the same kind of seed are always alike. You will need to provide several kinds of seeds.

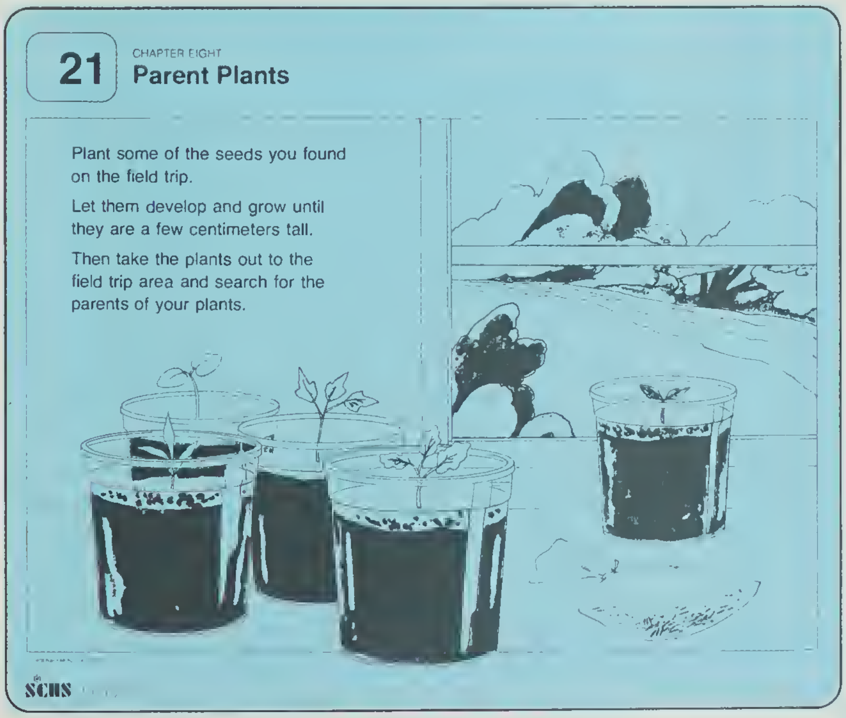
Put soil in a few planters and plant seeds in each one. Use several kinds of seeds but put only one kind in each planter. Label each cup with the kind and number of seeds planted and use a toothpick to mark the location of each seed. As a plant appears above the soil, remove the toothpick. When most of the plants have appeared, dig up the seeds still marked by toothpicks; the children should find either that these seeds have not germinated or that they have not yet reached the surface.

Can one seed develop into two or more plants? After planting seeds, children often inadvertently move them, so that two plants appear together. Some children misinterpret this as two plants coming from one seed. Have them plant five seeds, then count the number of plants that appear. The evidence should help them understand that a seed produces only one plant.

Cleanup. The plants, seeds, and papers may be discarded now. Rinse and air dry the cups.

EXTENDING YOUR EXPERIENCE CARDS

21. Parent Plants. Determine if the child who wants to do this activity understands that she will find the parent plants by comparing the offspring to many plants in the field trip area until she finds some that match the plants she grew from seeds.



21 CHAPTER EIGHT

Parent Plants

Plant some of the seeds you found on the field trip.

Let them develop and grow until they are a few centimeters tall.

Then take the plants out to the field trip area and search for the parents of your plants.

Extending Your Experience cards 1-21 are now available for the children's use. For materials needed, refer to the equipment list accompanying the set of cards.

CONCEPT / PROCESS EVALUATION

If you choose to evaluate the children's understanding of plant growth and development, turn to page 95 of the evaluation section at the back of the guide.

Part Three

From Eggs to Animals

OBJECTIVES

To identify eggs.

To differentiate animal eggs from plant seeds.

To conduct an experiment to find out if objects are seeds or eggs.

To record the development of eggs into larvae.

BACKGROUND INFORMATION

All female animals have eggs. All young animals develop from eggs, though different kinds of eggs may vary widely in appearance.

Just as seeds contain all the chemical messages necessary for the development of plants, so do eggs provide messages for producing new animals. In most cases, however, the eggs must be fertilized before

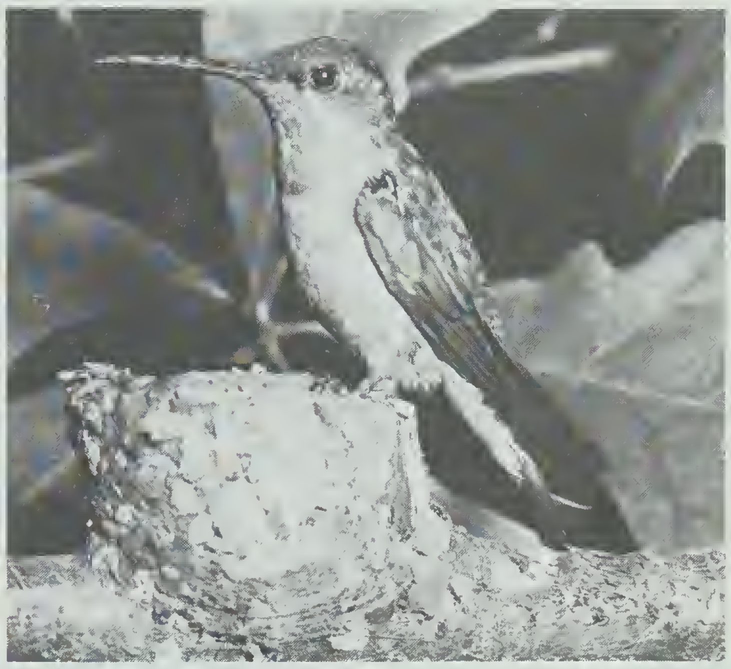
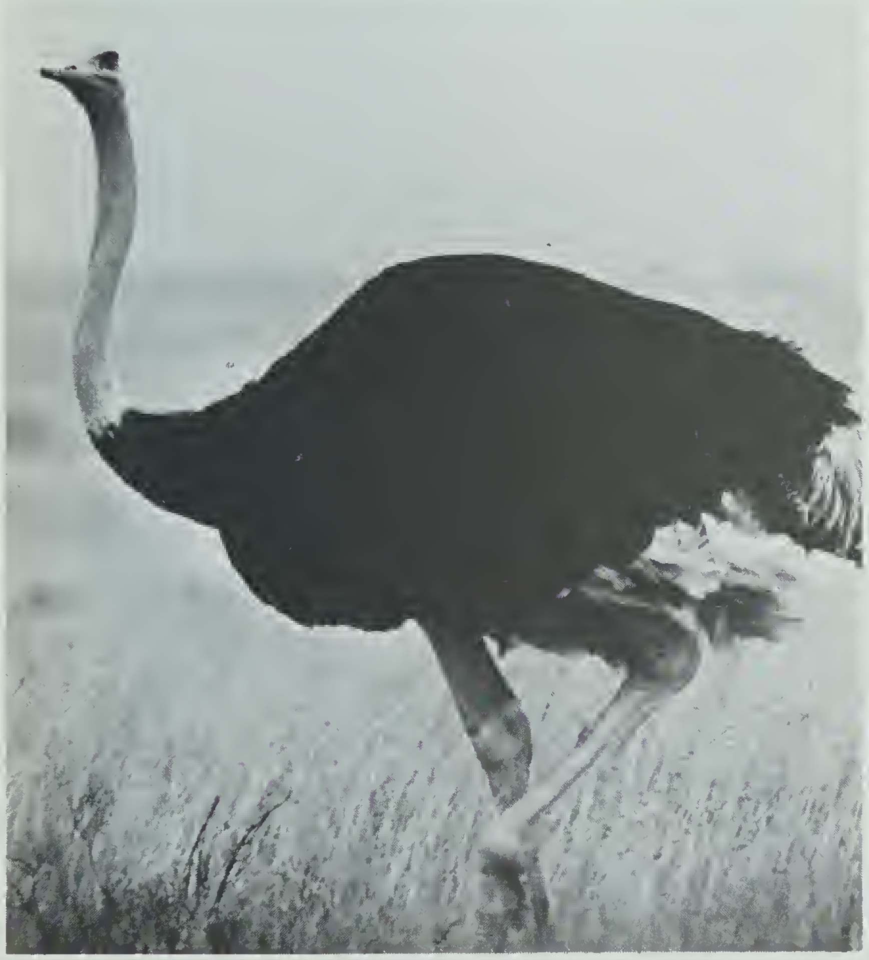
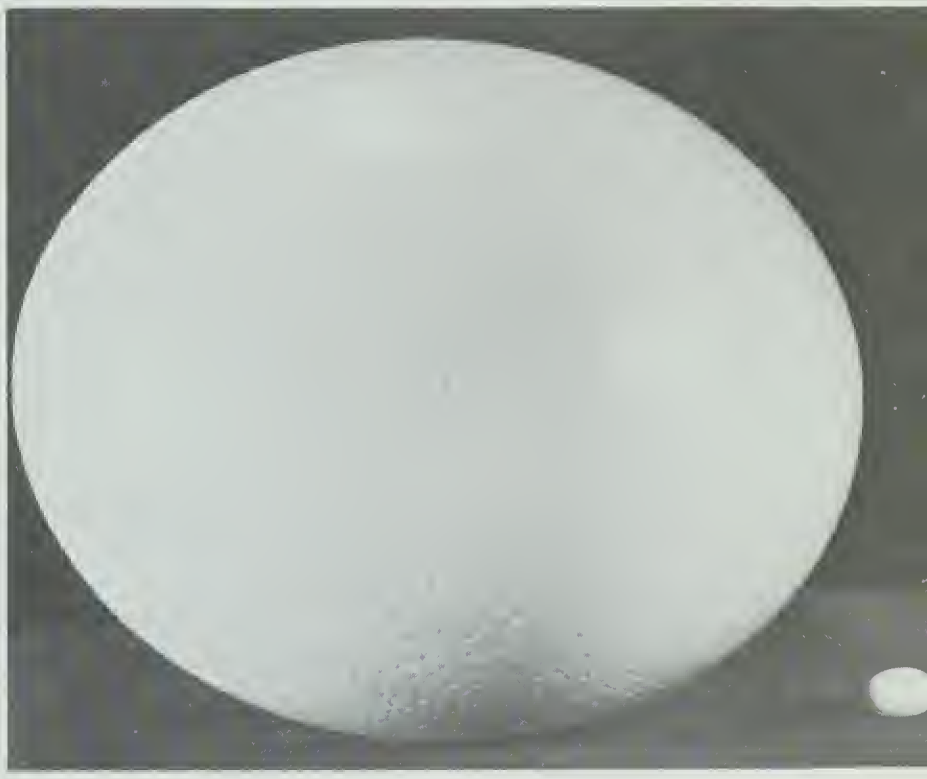


Figure III-1. An ostrich *(below)*, a hummingbird *(right)*, and ostrich and hummingbird eggs. In this case, egg size is a reflection of the size of the animal producing it.





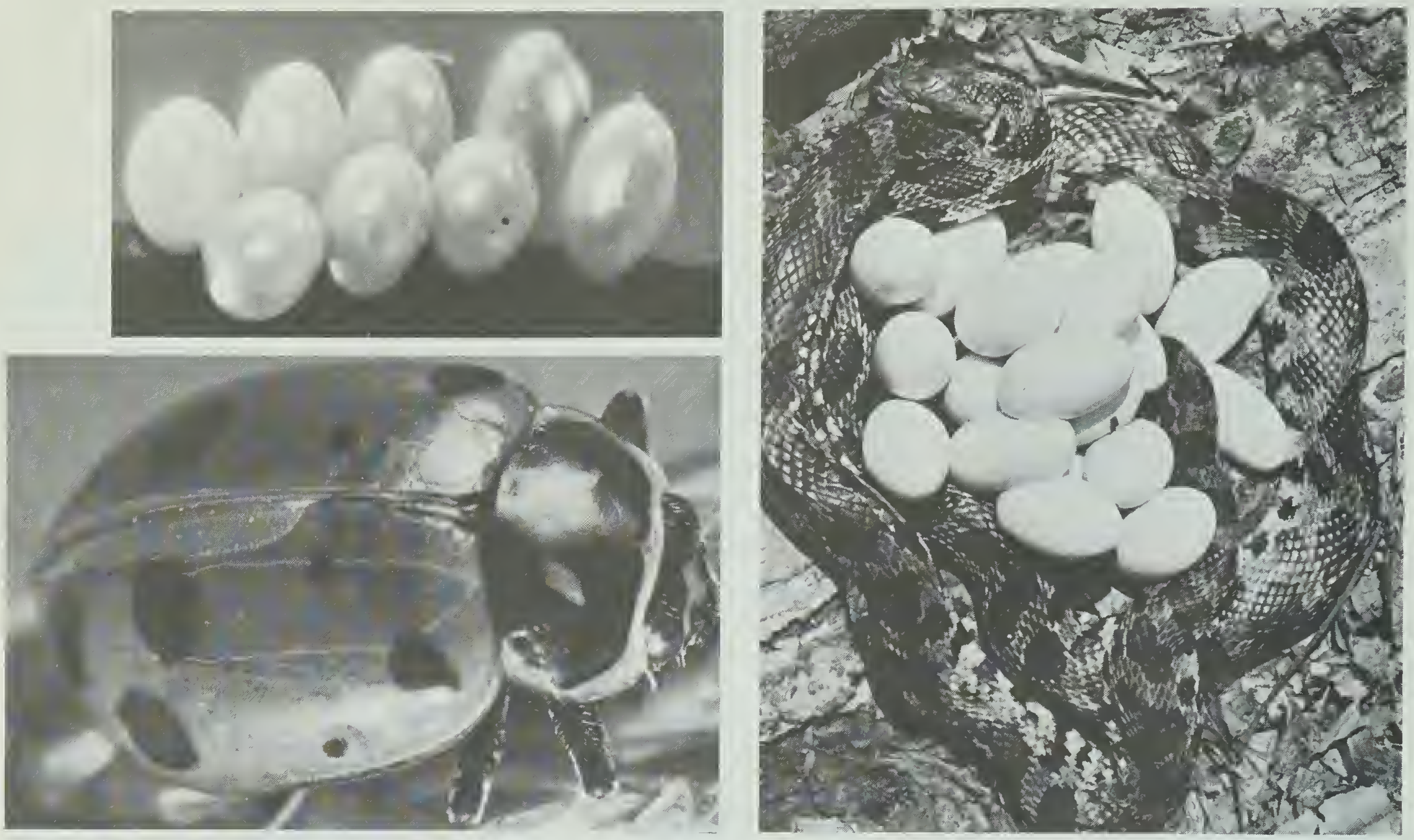


Figure III-2. *Left:* a ladybird beetle and eggs (magnified 25 times). *Right:* a fox snake with eggs.

they can develop further. During fertilization hereditary material from the father and mother are brought together in a new, unique combination.

Eggs that have the potential for becoming completely different kinds of animals may appear much alike. Even egg size is not definitely related to adult animal size, for a rather small egg may become an enormous animal. Variation in egg size is related to the amount of foodstuff, such as yolk, included; and that depends on whether and how long the food is used by the growing embryo. Even the eggs of a very large mammal, such as an elephant or a whale, can be very small because it receives food from the mother soon after being fertilized. A bird egg, on the other hand, must be large enough to hold the yolk that feeds the bird embryo until it hatches.

OVERVIEW

In Chapter 9, "Seeds or Eggs?" the children investigate seeds and eggs and do a simple experiment to distinguish between them. In Chapter 10, "Young Crickets and Tadpoles," the children see the frog eggs develop into tadpoles. In Chapter 11, "Development and Growth of Animals," children continue their observation of tadpoles and study cricket egg development.

GETTING READY

You will need "aged" water or pond water for the next several weeks. Prepare about 12 liters as directed on page 106.

Several days before beginning Chapter 10, prepare some uniformly moist soil for the cricket eggs by adding enough water to a large soil-filled zip lock bag to darken the soil. A pinch of this soil should almost drip water after it has been sealed in the bag for three or four days.

About three weeks before you begin Chapter 12, order Live Organisms shipment LC-2. Order Live Organisms shipment LC-3 about three weeks before you begin Chapter 14. (The mealworms and caterpillars in shipment LC-3 may be sent to you in separate mailings.)

Read the instructions for the optional activity on raising chicken eggs, page 53. If you decide to carry out this activity, you will need to make arrangements now for obtaining fertilized eggs and setting up an incubator.

9 Seeds or Eggs?

SYNOPSIS

Children compare seeds with eggs.

Children conduct simple experiments to determine which objects develop into plants and which develop into animals.

Suggested time: ***one session to set up, then another session a week later***

TEACHING MATERIALS

For each child:

student manual page 18

For each team of two children:

5 frog eggs†

Drawer 2

1 magnifier

Drawer 4

1 tumbler

Drawer 5

5 radish seeds
2 toothpicks

For the class:

10 cricket eggs†
tadpole food†
soil‡
vermiculite‡
8 liters (2 gal) aged or pond water*
1 chicken egg*
scissors*
index card*
cutoff milk cartons*
4 sheets (8 x 13 cm, or 3 x 5 in) black construction paper*
pencils*

Drawer 3

8 small plastic zip lock bags

Drawer 4

2 dip nets
2 large fluted containers

Drawer 5

6 water sprinklers

* provided by the teacher
† in Shipment LC-1
‡ in Sand and Soil box

ADVANCE PREPARATION

This activity requires Live Organisms shipment LC-1, which should have been ordered three weeks ago.

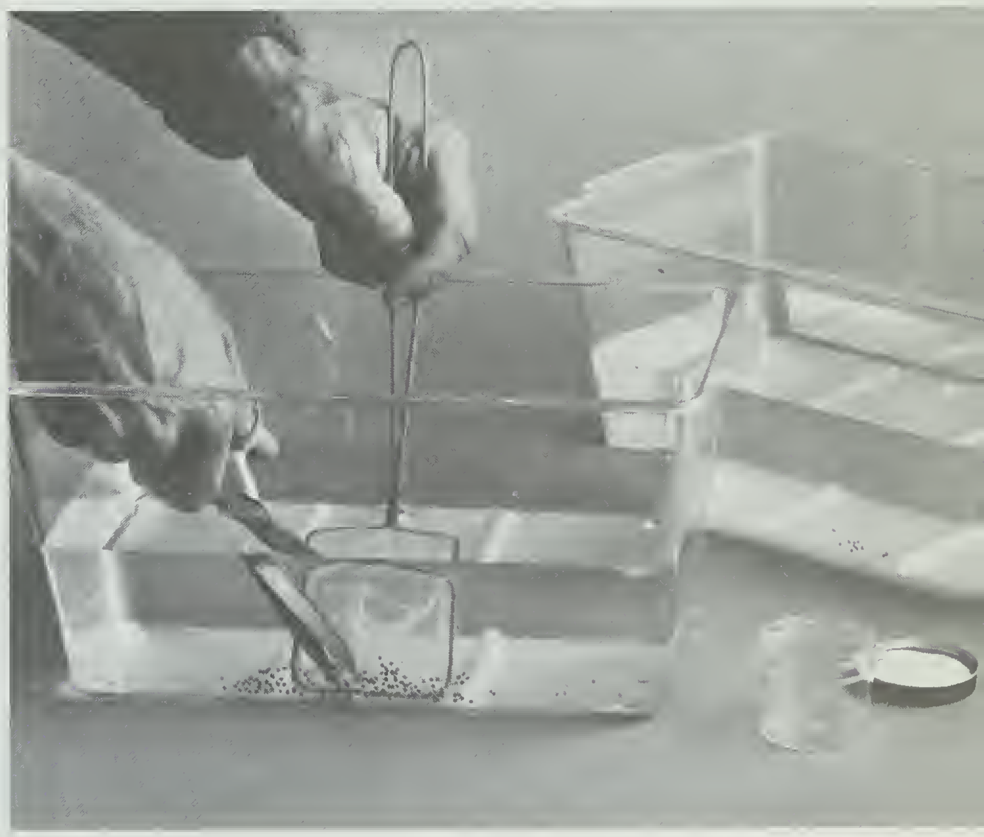
- The water you use is very critical. The water in each community varies greatly, and much of the tap water we drink will harm frog eggs. Whenever possible, use water which is proven safe for small animals, such as that from ponds, lakes, or rivers in which fish and other animals normally live. Of course, the containers in which you transport this water must also be free of harmful substances. Refer to the explanation on page 106 for the type of water and the treatment that might be necessary a week before you expect shipment LC-1 to arrive.

Half fill two of the large containers from the kit with the prepared water and put the frog eggs in one of them. A fish net is the best tool for holding the egg mass while you cut it (Figure 9-1). Using clean scissors, snip off clusters, of five eggs each, from the egg mass. Be careful not to cut into the eggs.

As you separate the eggs, use the fish net to transfer the clumps of eggs to the other container. The children will draw their organisms from this acquarium when they set up their own containers. Half fill each of four tumblers with aged water and add a cluster of five eggs to each. These four tumblers will serve as display containers for the children.

Select a storage place for the children's containers.

Figure 9-1. Cutting the frog egg mass.



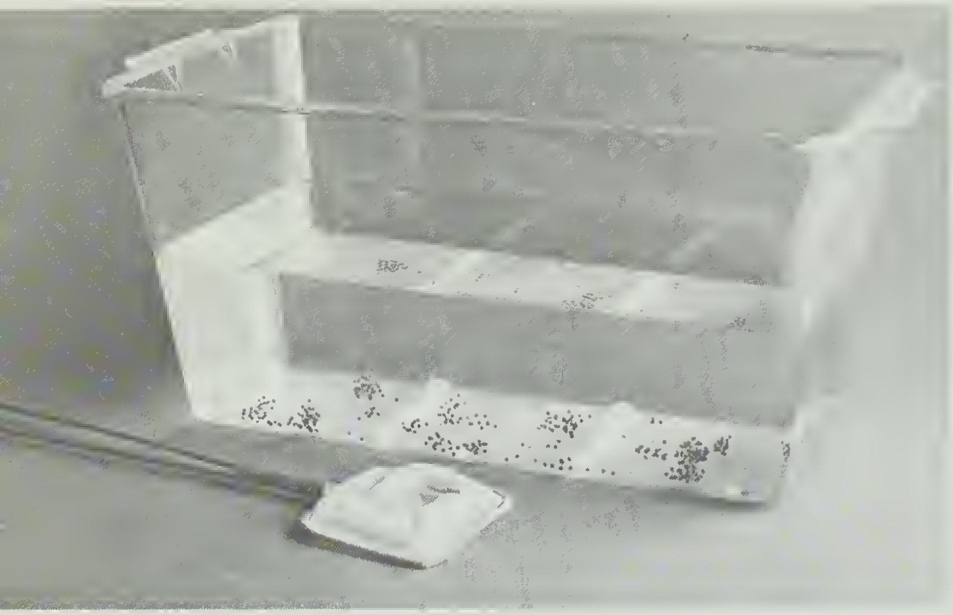


Figure 9-2. Frog egg clusters ready for distribution.

This spot should not be in direct sunlight or in any place that is warmer than 27°C (80°F).

Pour the packet of radish seeds into an empty tumbler. Do the same with about sixteen soybean pods. Don't label the tumblers or tell the children that these are seeds.

Open the container labeled Cricket Eggs and remove about ten eggs (including some soil). Separate the eggs from the soil by gently touching the moistened corner of an index card to the eggs. The eggs will stick to the card. Reseal the original container. Transfer the eggs to a piece of moistened black construction paper. Place the paper and eggs in an empty tumbler. The cricket eggs must remain moist; if you have prepared this enough in advance that the eggs may dry out, cover the tumbler with a plastic bag or plastic wrap.

TEACHING SUGGESTIONS

Children work with seeds and eggs in the discovery phases of "growth and development" and of "plant and animal."

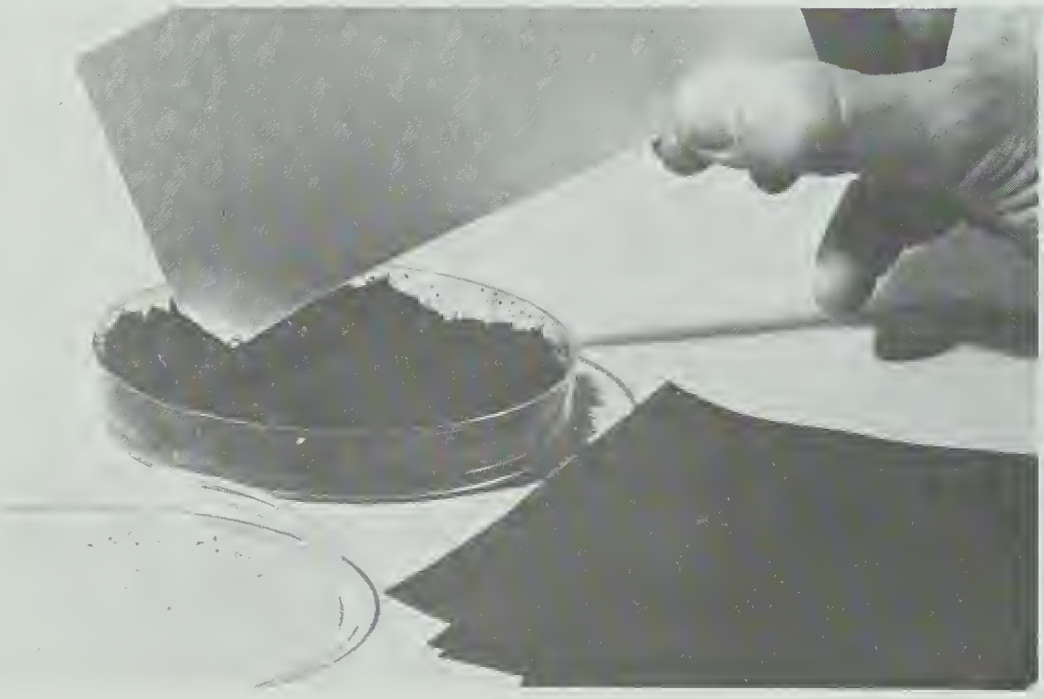
Investigating familiar and new objects. Gather the children in a large semicircle around you and tell them you have some new objects for them to see today. Also say that because these objects can be easily damaged, they should be handled gently. The children should not put any of these objects in their mouths.

Distribute two or three radish seeds to each child and ask the children if they think these are plants or animals. They should have little trouble identifying these seeds, because they have seen them previously. Withhold your judgment on these objects and those which follow until the experiments are finished.

Then, without revealing what they are, show the children some cricket eggs. Using a moistened index card, remove two eggs to each of four pieces of moistened black construction paper. Let everyone see these objects on the paper. Magnifiers are helpful at this point so have a child distribute those, too.

When the children have had an opportunity to observe these new objects (eggs), ask them if they think the objects are plants or animals. You will

Figure 9-3. Transferring cricket eggs.



probably receive both of these answers and possibly some others as well.

Hold up a chicken egg next. Ask first what it is, next where the children think it came from, and then whether they think it is a plant or an animal. You will probably find that some children think chickens are not animals.

Display one of the tumblers of frog eggs you prepared and pass around the other three. Again, inquire if the children think these objects are from plants or animals.

Classifying objects as plants or animals. You now have distributed quite an array of display materials. Encourage the children to suggest characteristics you could use in sorting these objects into a plant group and an animal group.

During this sorting, listen to the reasons the children offer for assigning an object to the plant or animal group. These explanations will help you to guide your pupils in setting up their experiments.

Remember, having had little experience with these living objects, children should not be expected to know the correct answers. Rather, the purpose is only to show the objects, raise questions, and later to see what those organisms turn into. What they become when they develop is the evidence for the children.

There will be at least some uncertainty on the part of the children if not some obvious question, such as, "What is it?" Instead of answering with, "It's a frog egg" or other solutions, ask, "How could we find out?" or a similarly worded question. The children may suggest waiting, planting, trying to "grow" the organisms, etc. Encourage these suggestions and suggest that they do an experiment to find answers.

Invite proposals from the children. Most children can propose simple experiments that allow further development of the organism in question.

Experiments. Tell the children that each team of two can have some of the round, black objects in a tumbler of water so they can watch to see what develops. This gives them an example of one kind of experiment they can do. Tell them first that these objects are live organisms which must live in water. Then show the children the procedure for setting up a tumbler:

- Using a pencil, label the frosted rim of a tumbler with your name and the date.
- Add aged water to the labeled tumbler until the water level reaches the lower line of the frosted section.
- Using a fish net, transfer a cluster of five frog eggs from the aquarium to the tumbler (Figure 9-4).

After your demonstration, show the children the materials and let them begin their preparation. Have each team of two share a tumbler. You should monitor the children when they are transferring the eggs to see that they don't squash the eggs or contaminate the water with dirty hands (Figure 9-5).

After the children have used magnifiers to observe the eggs, show them where the eggs can be stored.

Thereafter, have the children observe the eggs every day. If the water level drops below the bottom edge of the frosted section, more aged water must be added.

Extending Your Experience card 23 (page 54) requires frog eggs. Any student who uses that card must begin at this time.

Now that the children have set up their frog egg containers, direct their attention to the other objects you showed them. Ask the youngsters how they might find out what those other organisms will develop into. Some children will suggest planting in soil or vermiculite, others may suggest placing the organisms in water. Encourage teams of two to "plant" two of each organism. The zip lock bags, planter cups, soil, vermiculite, sprinklers, etc., should be made available for their experiments. As you visit each team, remind the children to label their setups with their names and the date. Also encourage the students to tape one of the organisms they "planted" to the outside of the container in which the organism is being developed. Remind them to water the setups to keep the soil moist over the next week or so.

Figure 9-4. Demonstrating how to prepare the frog egg tumbler.

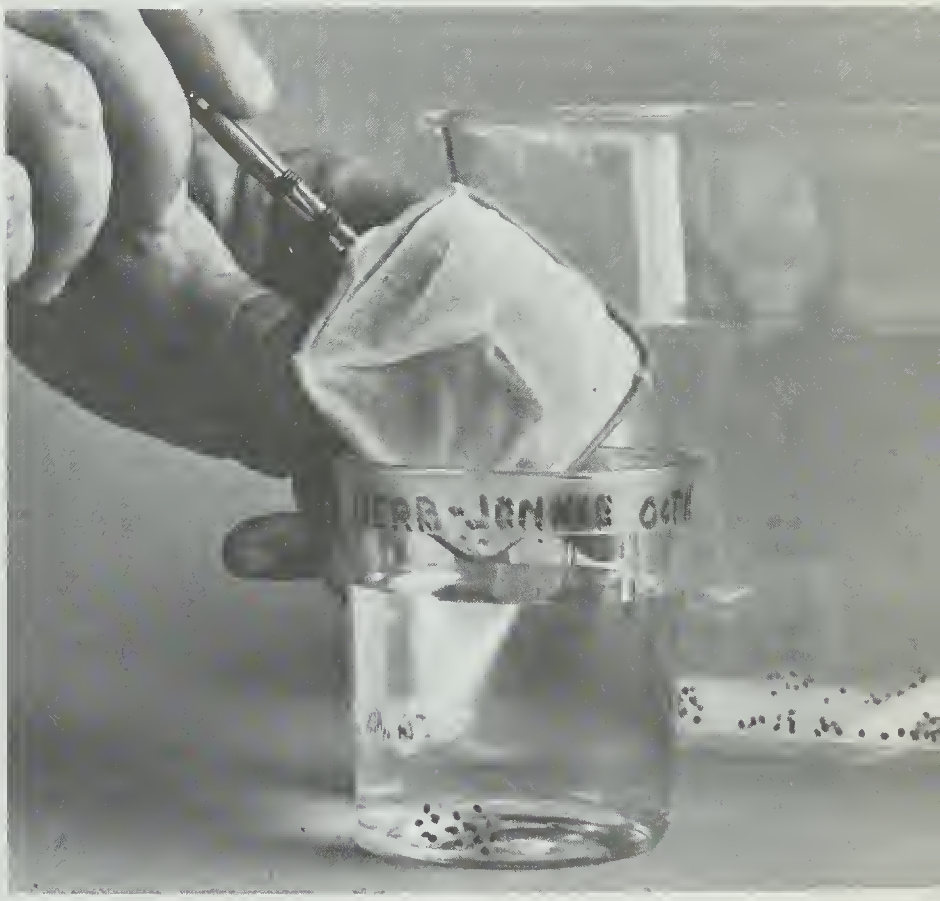
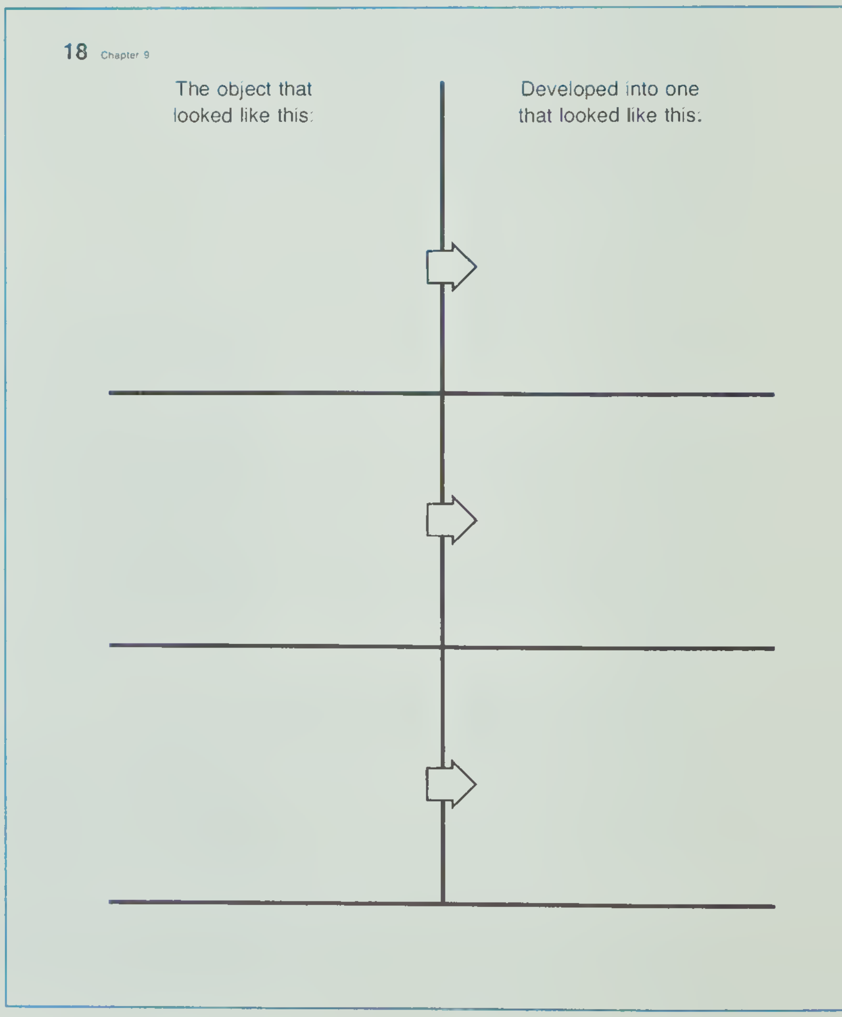


Figure 9-5. Setting up eggs in a tumbler for two.

Using student manual page 18. At this time, have the children draw a picture of each of their organisms in the left column. Later, when the organisms have developed, they can show what these objects became by drawing them in the right-hand column opposite the eggs or seeds from which they came.



18 Chapter 9

The object that looked like this:	Developed into one that looked like this:

Planning ahead. If you have not already prepared for Chapter 10 as explained on page 48, do so now. While you are waiting for development of seeds and eggs, proceed with Chapter 10.

Experimental results. The first event to occur will probably be the development of frog eggs into young tadpoles. Development of the cricket eggs will take longer, but some of the seeds may show signs of development soon.

Tadpoles. Some frog eggs will hatch very soon (one to three days), because they usually remain as eggs for only five days or so. When this happens, you can expect much excitement. First, the eggs elongate, then the organism wiggles until it is free of the supporting jellylike substance.

- Not all the frog eggs will hatch. In some classrooms, none of them will. This is disappointing, but so many factors can stop development that this happens sometimes. The percentage of eggs that hatch in natural settings is very low, and frog populations probably survive only because the animals lay eggs in such large numbers.

Crowding. As the tadpoles grow, they will occupy more space, leaving less room for themselves and others. If all five tadpoles survive in one team's tumbler for two to three weeks, thin out the population by removing one and placing it in your large tadpole aquarium. As tadpoles continue to grow, thin out the populations so that those remaining in the children's tumblers can survive.

The children will probably refer to newly hatched eggs as babies. Tell them that these animals will become frogs some day and that baby frogs are called tadpoles. When their tails become very small, the tadpoles are called frogs.

Feeding tadpoles. If the children do not raise the question, explain that, like other animals, tadpoles must have food. Show them the container of tadpole food and tell each team to add *one* pellet of the food to the tumbler each school day. Very young tadpoles do not eat much. More than one pellet may foul the water, killing tadpoles.

Comparing results. Arrange for a sharing of observations and events so the children can see what happened in each other's tumblers. Also during this session, bring up the original question of what kind of organism this black object would develop into. It should now be clear that the organism was an animal even though it didn't appear to move or eat or breathe or make noise as animals often do.

"Inventing" the concept *eggs*. After the frog eggs become tadpoles and some of the seeds have developed into plants, encourage the children to review the results by contrasting the objects they "planted." "This plant had a big seed and this one was small," "The chicken egg was bigger than the soybean seed," and "The chicken egg will break, but seeds don't" are some obervations children have made in trial classrooms. Other contrasts of plants and animals will help set the stage for inventing the concept of eggs.

Tell the children animals start their life in eggs. Eggs are usually soft inside, and seeds are usually hard inside. Eggs are usually wet inside (like chicken eggs), and seeds are usually dry inside. Eggs come in many sizes just as seeds do. The chicken and frog eggs are examples of size difference.

Encourage the children to describe some eggs and seeds they have seen. When they have finished describing and telling about eggs and seeds, show the children a radish and a soybean and tell them the names. Also tell them the other long, whitish organism they have in one of their containers is an egg that will develop into a cricket.

Using student manual page 18. Have the children add the labels Seed and Egg to the appropriate blocks.

Cleanup. Send home or discard the radish and soybean plants. Rinsed milk cartons are excellent for this purpose. All cups and bags used for the plants should be rinsed, air dried, and returned to the kit. Keep a supply of aged water on hand for the tadpoles.

The containers of cricket eggs and your extra tadpoles will be used in following chapters.

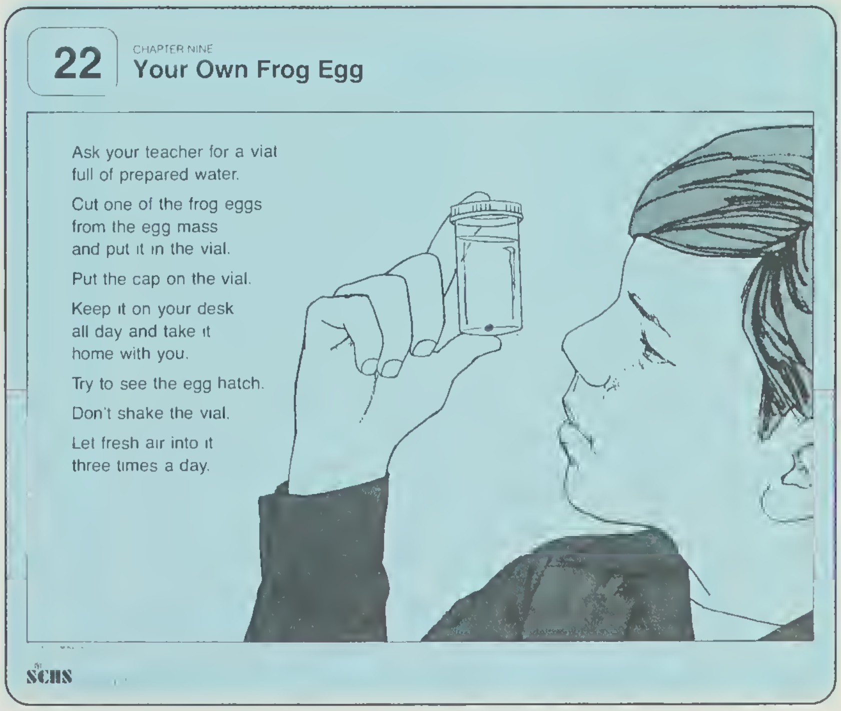
OPTIONAL ACTIVITIES

Field trip. Take the children on a field trip to find seeds and eggs. A weedy area will have a wide variety of seeds on the ground. Under the surface of the soil, snail and other eggs can be found. Eggs are much easier to find at a pond.

Raising chicken eggs. If you have experience incubating fertile chicken eggs and would like your students to see the event, this will fit in nicely with this chapter. Refer to *A Sourcebook for the Biological Sciences* by Morholt *et al.* or to *A Sourcebook for Elementary Science* by Hone (both published by Harcourt, Brace, and Jovanovich) for details. The activity requires about twenty-two days from incubation to hatching.

EXTENDING YOUR EXPERIENCE CARDS

22. Your Own Frog Egg. This activity will have to be done very soon after the frog eggs arrive. Encourage students who want to conduct this activity to prepare their setups right away. Be certain to supply them with prepared water. You will need to provide some vials or other capped containers that can be carried easily.



22 CHAPTER NINE
Your Own Frog Egg

Ask your teacher for a vial full of prepared water.

Cut one of the frog eggs from the egg mass and put it in the vial.

Put the cap on the vial.

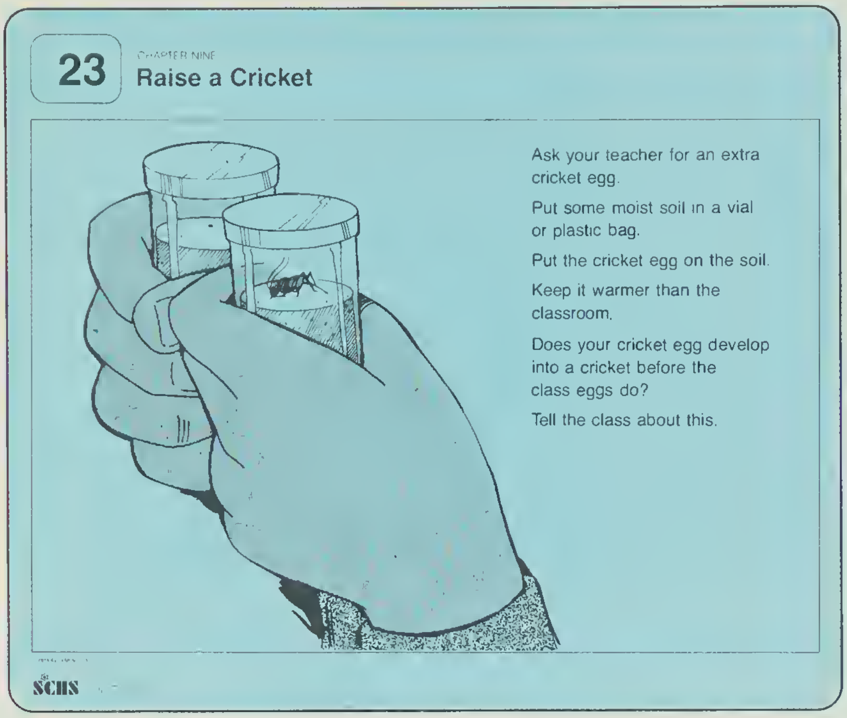
Keep it on your desk all day and take it home with you.

Try to see the egg hatch.

Don't shake the vial.

Let fresh air into it three times a day.

23. Raise a Cricket. The child doing this activity will need a vial, or other small capped container, in which to keep the cricket egg. If you have extra eggs, provide two or three. Encourage the child to make comparisons between these eggs and others in the classroom.



23

CHAPTER NINE

Raise a Cricket

Ask your teacher for an extra cricket egg.

Put some moist soil in a vial or plastic bag.

Put the cricket egg on the soil.

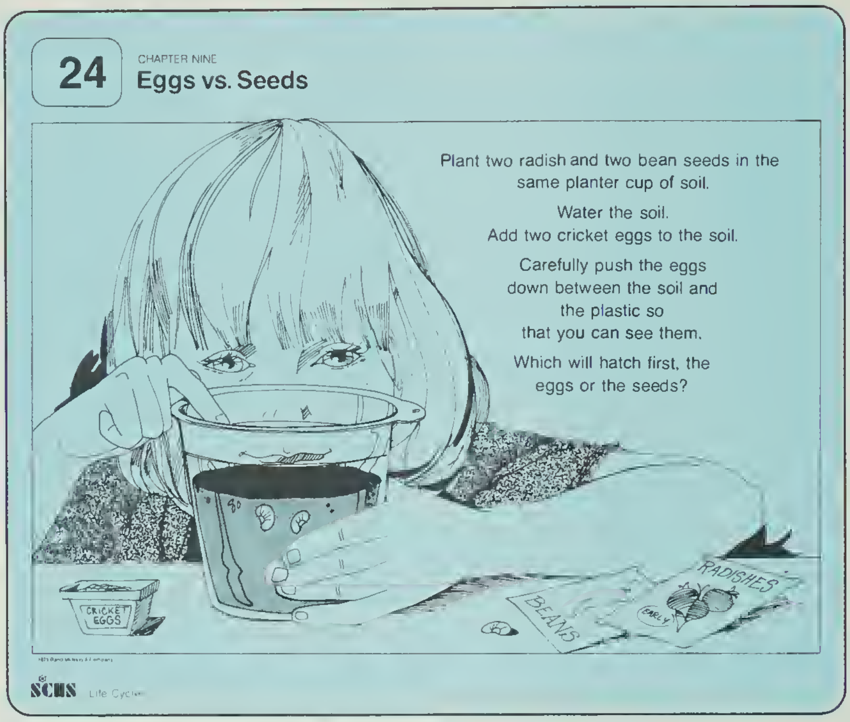
Keep it warmer than the classroom.

Does your cricket egg develop into a cricket before the class eggs do?

Tell the class about this.

SCIIS

24. Eggs vs. Seeds. The pupil doing this activity will need one label, one planter cup, a toothpick, some soil, access to water, two radish and two bean seeds, and two cricket eggs. Watch to see that the child does not let the soil dry out at the top where the egg is located. Cover the cup with plastic wrap, or other waterproof material if the soil cannot be kept moist.



24

CHAPTER NINE

Eggs vs. Seeds

Plant two radish and two bean seeds in the same planter cup of soil.

Water the soil.

Add two cricket eggs to the soil.

Carefully push the eggs down between the soil and the plastic so that you can see them.

Which will hatch first, the eggs or the seeds?

SCIIS Life Cycles

10

Young Crickets and Tadpoles

SYNOPSIS

Children set up cricket houses and observe the development of young crickets.

Children continue their observation of frogs.

Suggested time: *one class period to set up, with observation continuing over several weeks*

TEACHING MATERIALS

For each child:

student manual pages 19–21

For each team of two children:

4–6 cricket eggs†

Drawer 2

1 cricket feeder
1 magnifier

Drawer 4

1 tumbler
1 tumbler lid

Drawer 5

2 toothpicks

For the class:

tadpole food†
cricket food†
soil‡
black construction paper*
scissors*

Drawer 2

1 light source

Drawer 3

1 large plastic zip lock bag

Drawer 5

6 water sprinklers

* provided by the teacher
† Shipment LC-1
‡ Sand and Soil box

ADVANCE PREPARATION

Not more than one hour before the children will construct their cricket house, place about five eggs in a cricket feeder for each team. The children can help you separate the eggs from the soil in which they were shipped. If your air is very dry, add a small, wet, crumpled paper towel to the depression in which you placed the eggs.

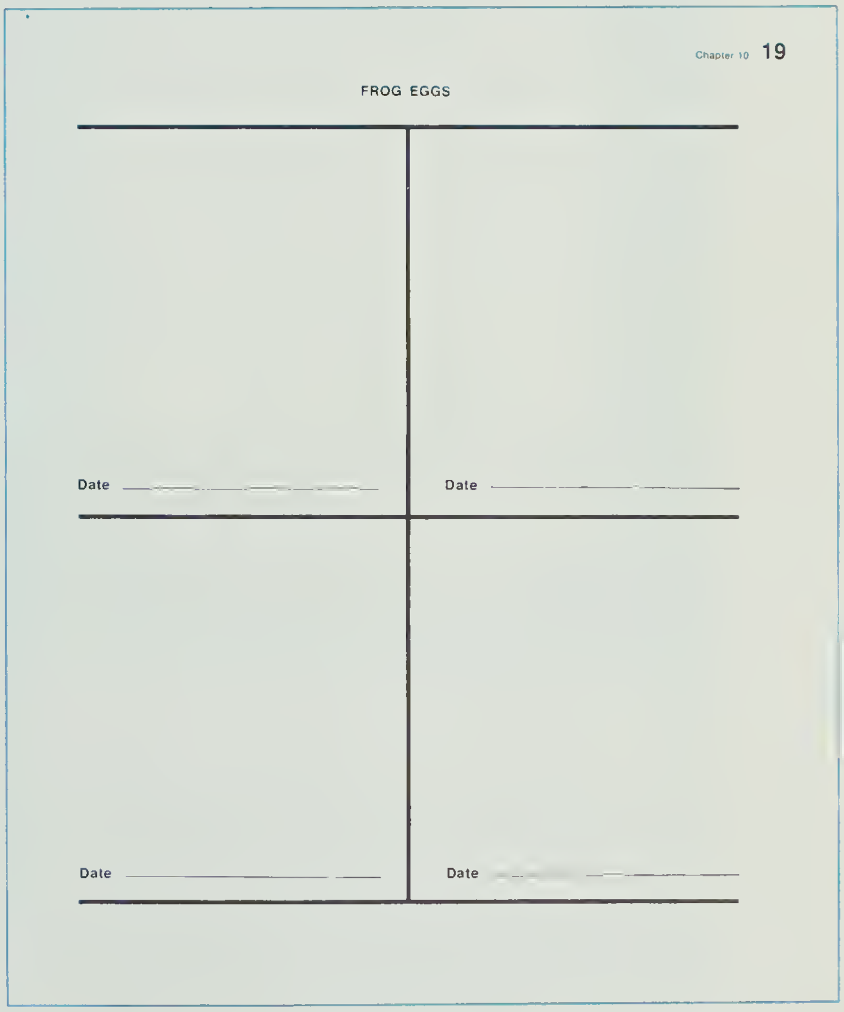
TEACHING SUGGESTIONS

In watching the growth and development of animals, children continue the discovery phase of that learning cycle.

Tadpoles. Although the eggs develop into tadpoles in only a few days, the tadpole changes to an adult frog over a period of months or not at all. Most of the tadpoles will die. Some will grow quite large, a few may develop legs, and a very few will become adult frogs.

Using student manual page 19. The children can record the development of the frogs by drawing sketches on this page weekly.

Making cricket houses. Gather the children and the cricket egg experiments they set up in Chapter 9 to



Chapter 10 19

FROG EGGS

Date ____________ Date ____________

Date ____________ Date ____________

determine if the cricket eggs were plants or animals. Some of the eggs may have hatched. If so, the children can tell you the unknown organisms were animals and that any more eggs which look like that should be kept in moist soil.

Tell the children they can set up their own cricket houses with eggs. (Follow these instructions yourself first, making a cricket house as a demonstration for the children.)

- Have each team get one tumbler and a ventilated lid, then label the tumbler with the students' names and the date the cricket eggs were laid. (You read the date to them from the label on the cricket egg shipping container.)
- Now have each team get a little of the wet soil you prepared earlier and place it in the bottom of each tumbler. The soil surface should be 2 cm (about 1 in) above the bottom of the cup.

After the cups have been prepared, one member of each team can get that team's cricket eggs from you. Give each team a magnifier and a cricket feeder containing the five eggs you placed in it.

The feeder should be positioned in the center of the tumbler and pressed into the soil until the rim is only slightly above the soil, as shown in Figure 10-2. (This will allow the cricket to climb into the feeder later.)

Distribute two toothpicks and a large drop of water to each team. (The water may be placed on a desk or tabletop.) Ask the children to make five small holes in the soil next to the side of the cup, so they will be able to see the eggs from the outside. Explain that they can pick up a cricket egg just by touching it with the small end of a toothpick they have wetted in the drop of water. Using this technique, they should transfer one egg to each hole. Unless the holes are very large, the eggs should not be covered. All eggs should contact the moist soil. Place the ventilated lids on the cricket houses, as in Figure 10-3.

Storing the cricket houses. Place the cricket houses where they will not receive direct sunlight or become hotter than 27°C (80°F). You may want to keep the frog egg tumblers and the cricket houses in the same part of the classroom, as their temperature requirements are similar. Have the children observe the cricket eggs every day or two, perhaps at the same time they observe their tadpoles.

Using student manual page 20. The children may use the spaces for their sketches of developing crickets. Although the eggs have not yet hatched and there is not yet enough information for the students to write their story on student manual page 21, you may want to suggest they draw a picture of their five eggs somewhere on that page to remind them of how the crickets began their lives.

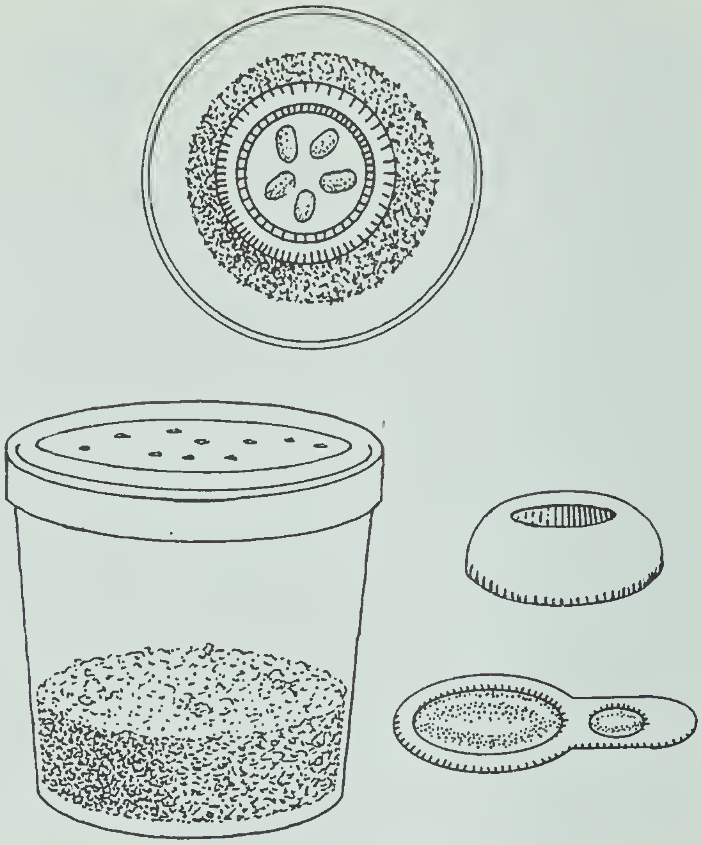
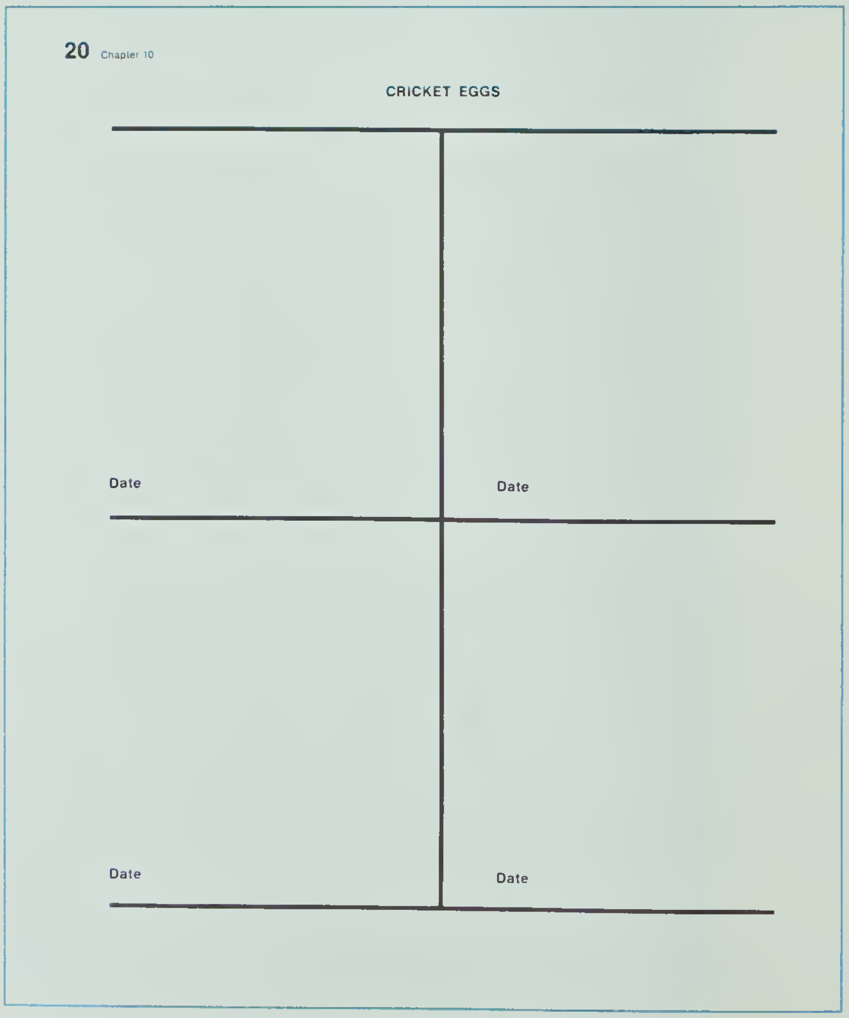


Figure 10-1. Each team gets these materials.



20 Chapter 10

CRICKET EGGS

Date	Date
Date	Date

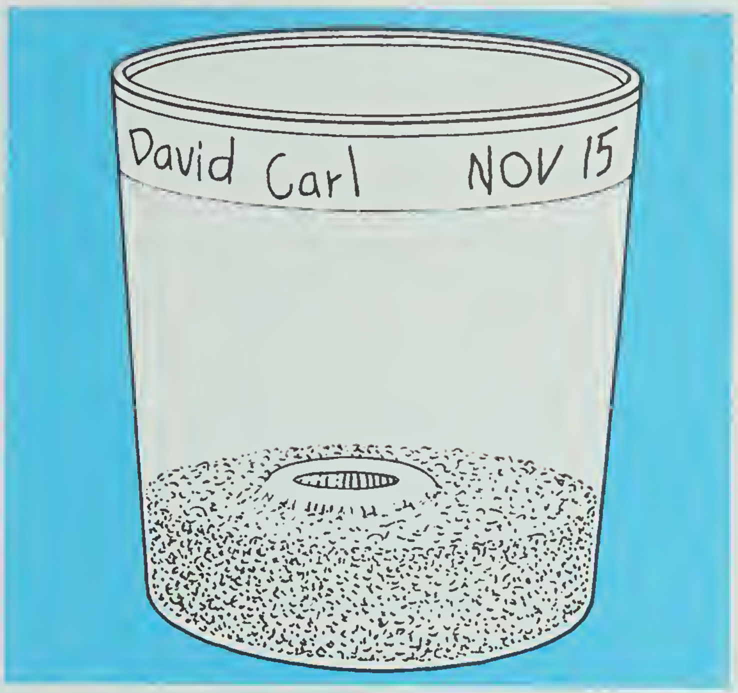


Figure 10-2. Press the cricket feeder into the soil.

Cricket nymphs. About eighteen days after they were laid, the cricket eggs will hatch. The emerging crickets are not always noticed by the children right away because they are so small. When they do see the newly hatched crickets (called *nymphs*), encourage the children to look at them through the magnifiers. Tell the children to record the date and to make a drawing on student manual page 20.

Feeding the crickets. A pinch of cricket food (the amount is not critical) should be added to the feeder. No water is necessary until the soil becomes dry. When water is added to the soil, a few drops from a sprinkler are sufficient.

Cut some black construction paper into a 3 cm x 5 cm (1″ x 2″) rectangle and fold it crosswise into a tent. Tell the children you will put this little tent in the soil of your cricket house so the crickets can climb onto it in case the soil ever gets too wet for them. The children should do the same for their cricket houses.

Temperature for crickets. A day or so after the crickets have hatched, rearrange their environment so they are a little warmer than before. You can move the light source closer to the cricket containers or move the crickets into the sunlight. If you move the crickets, do it as school begins one day so that you can monitor the temperature to see that it does not rise above 35°C (95°F) before the end of the school day. Adjust the light source as necessary. This increased temperature will hasten cricket development, but it will also cause greater water loss, so be certain that the children keep the soil moist.

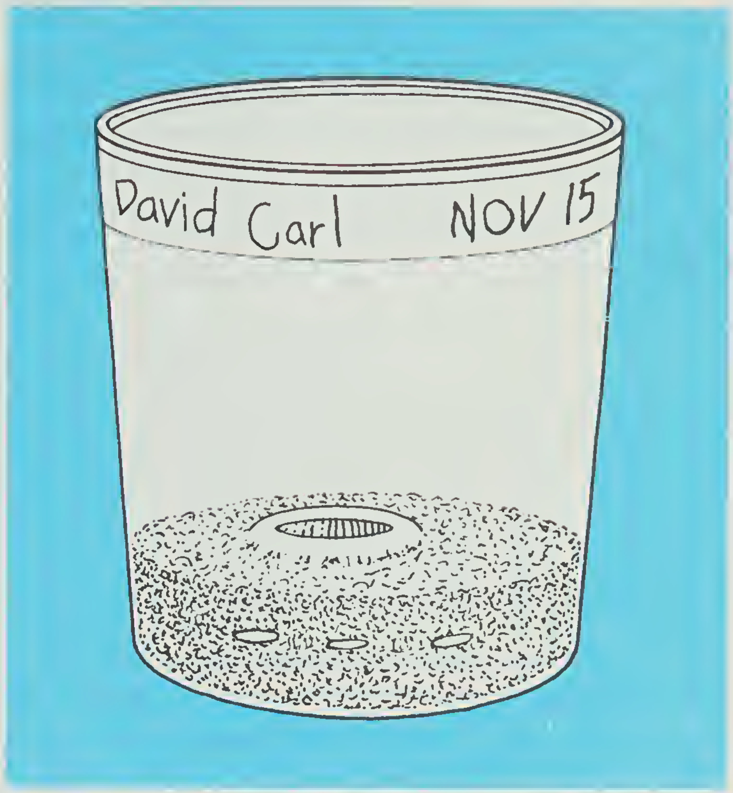


Figure 10-3. A prepared cricket house.

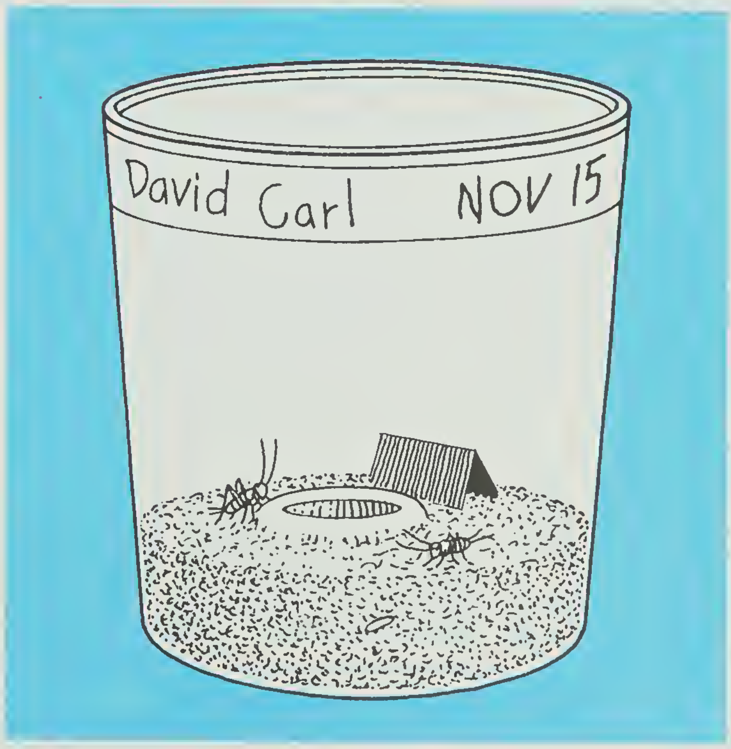


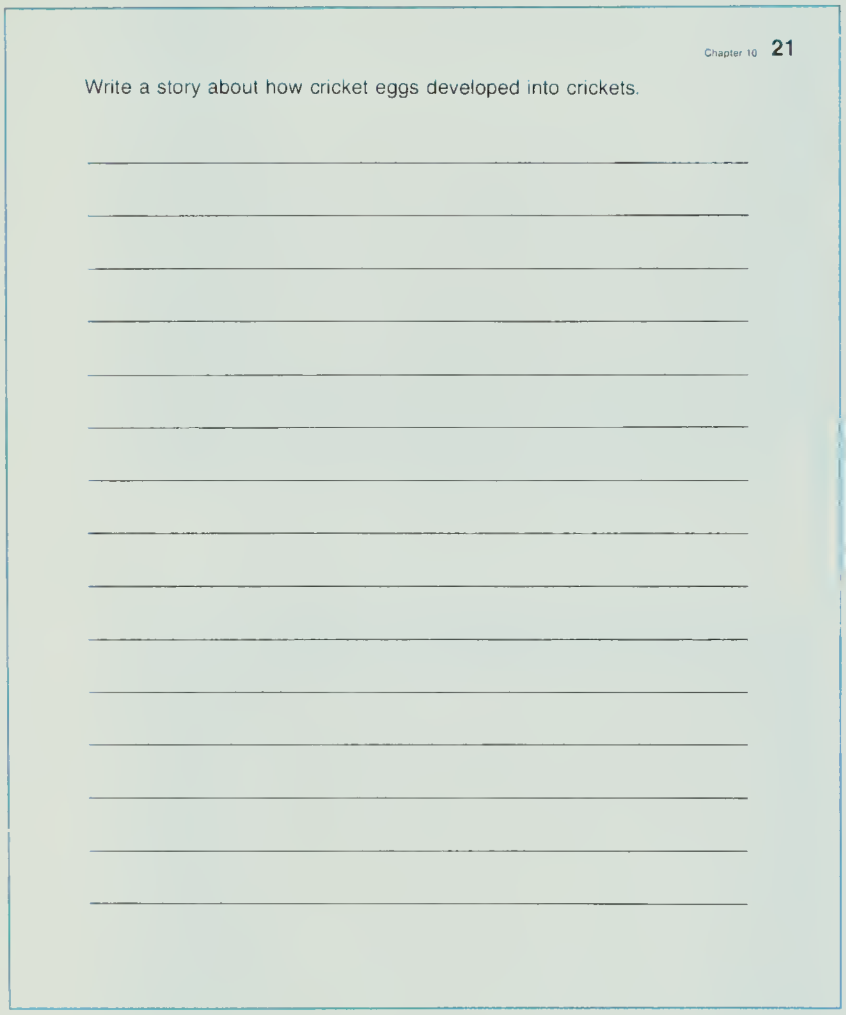
Figure 10-4. The paper tent provides a dry place for the crickets.

For about the next two weeks, see that the children observe, feed, and water their tadpoles and crickets every other day. Once a week, encourage them to record the changes on page 20 in their manuals.

About a week after crickets appear, direct the children's attention to student manual page 21.

At about the same time, begin Chapter 11, before the crickets and tadpoles grow too large.

Using student manual page 21. You may want to have the children tell a story aloud instead of writing it. The purpose of the page is to reinforce the concept that a cricket begins life as an egg and then develops into a very different looking animal. They may have expected this animal to grow very fast—another common misconception when youngsters have not had opportunities to watch growing organisms.


Chapter 10 21

Write a story about how cricket eggs developed into crickets.

OPTIONAL ACTIVITY

Cricket food. Crickets will eat quite a variety of cereallike foods. The children can test their breakfast cereals by bringing in a few flakes of as many different kinds of cereals as possible and determining which ones are preferred by the young crickets.

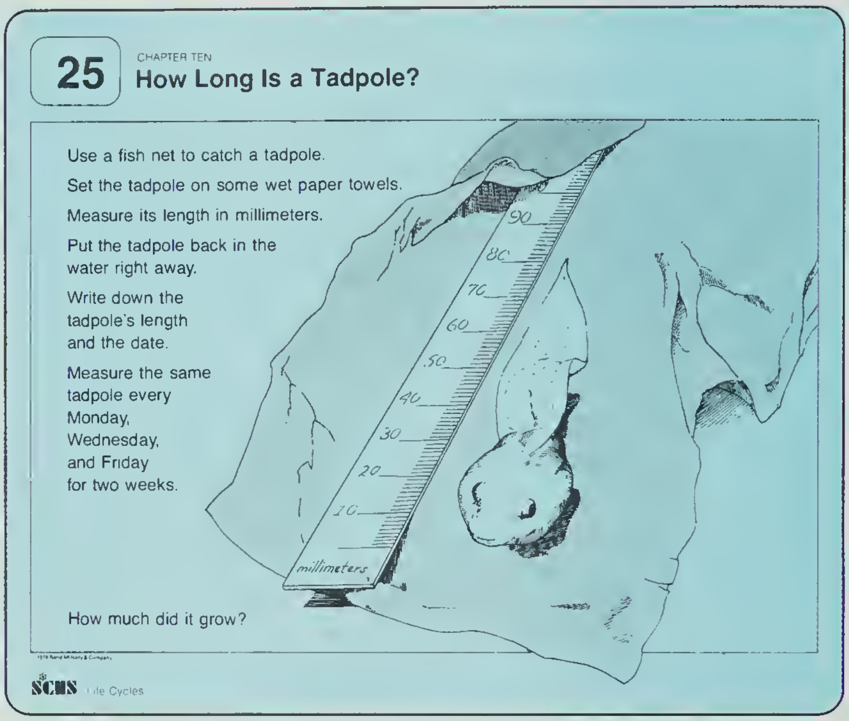
Cut strips of tagboard or file folders about 4 cm x 30 cm (2 in x 15 in), use a dab of rubber cement or glue to secure two flakes of one kind of cereal to the tagboard, and print the name of the cereal above the flakes. Keep adding cereals and their names. Carefully insert the baited tagboard into the bottom of a dry 6-liter container where the crickets can reach the cereals. Add a moist paper towel and some crickets to the bottom of the container.

See which cereals are preferred. Other foods may be tested using the same idea.

Cleanup. There is no cleanup at this time, because both the tadpoles and crickets will be observed further in the following chapter.

EXTENDING YOUR EXPERIENCE CARD

25. How Long Is a Tadpole? The child doing this activity will need a ruler, paper towel, the same tadpole from measurement to measurement, and a record sheet and pencil.



25 CHAPTER TEN
How Long Is a Tadpole?

Use a fish net to catch a tadpole.
Set the tadpole on some wet paper towels.
Measure its length in millimeters.
Put the tadpole back in the water right away.
Write down the tadpole's length and the date.
Measure the same tadpole every Monday, Wednesday, and Friday for two weeks.

How much did it grow?

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SCIIS Life Cycles

11 Development and Growth of Animals

SYNOPSIS

Children observe and record the growth of their tadpoles and crickets.

Children compare development and growth in animals and plants.

Suggested time: *two class sessions, plus optional repeat visits of animals*

TEACHING MATERIALS

For each child:

student manual page 22

For each team of two children:

crayon (optional)*
cricket feeder and crickets (from Chapter 10)

Drawer 5

metric ruler

For the class:

aquariums with frog eggs (from Chapter 10)
guest animals, including humans*

* provided by the teacher

ADVANCE PREPARATION

The tumbler-size tadpole aquariums and the cricket houses from Chapter 10 will be needed for this chapter. Also, locate and arrange for the loan of baby animals other than frogs and crickets. These may be cats, dogs, mice, hamsters, humans, or any other very young animals that the children can contrast with crickets and frogs.

TEACHING SUGGESTIONS

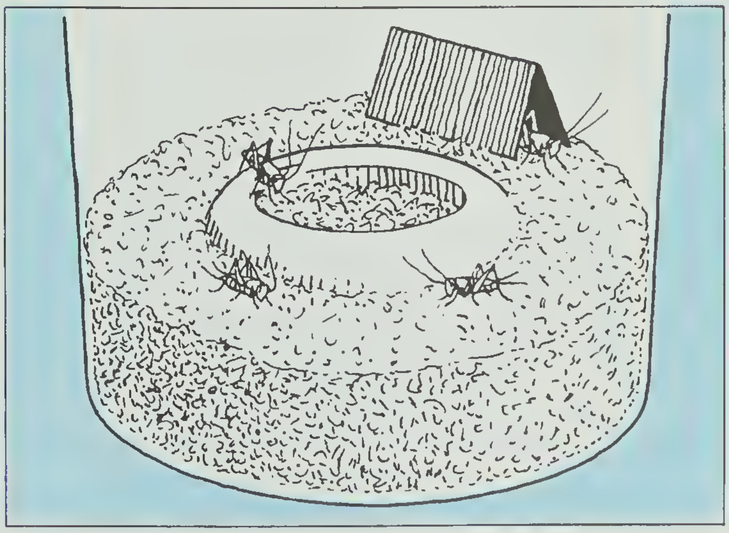
This is a continuation of the activities in Chapter 10. Like Chapter 6, this chapter provides a discovery activity in development and growth—here, in animals rather than in plants. There is no reinvention of development and growth although a review of the terms is included and they are used frequently.

Discovery of development in animals. As the tadpoles and cricket eggs develop, call the children together to tell and show you what is happening. In this way, teams whose cricket eggs may not yet have hatched can see the nymphs.

Ask the children to describe any changes in the form of the frog egg or tadpole or cricket egg. Notice whether they use or remember the term *development*. If they don't, remind them that the word is used to mean that an organism has gotten a new part. The cricket egg develops into a cricket, with eyes and antennae; a tadpole develops legs and lungs in becoming a frog; and so on.

The children can probably tell you about the development of their plants, and you can weave that into a discussion of how animals also develop. As development of the animals continues, take advantage of the opportunities for the children to discover how all plants and animals go through developmental states.

Figure 11-1. Young crickets.



Discovery of growth in animals. As the tadpoles and the cricket nymphs grow, call the children's attention to growth in animals and encourage them to compare it to the growth they observed in their plants.

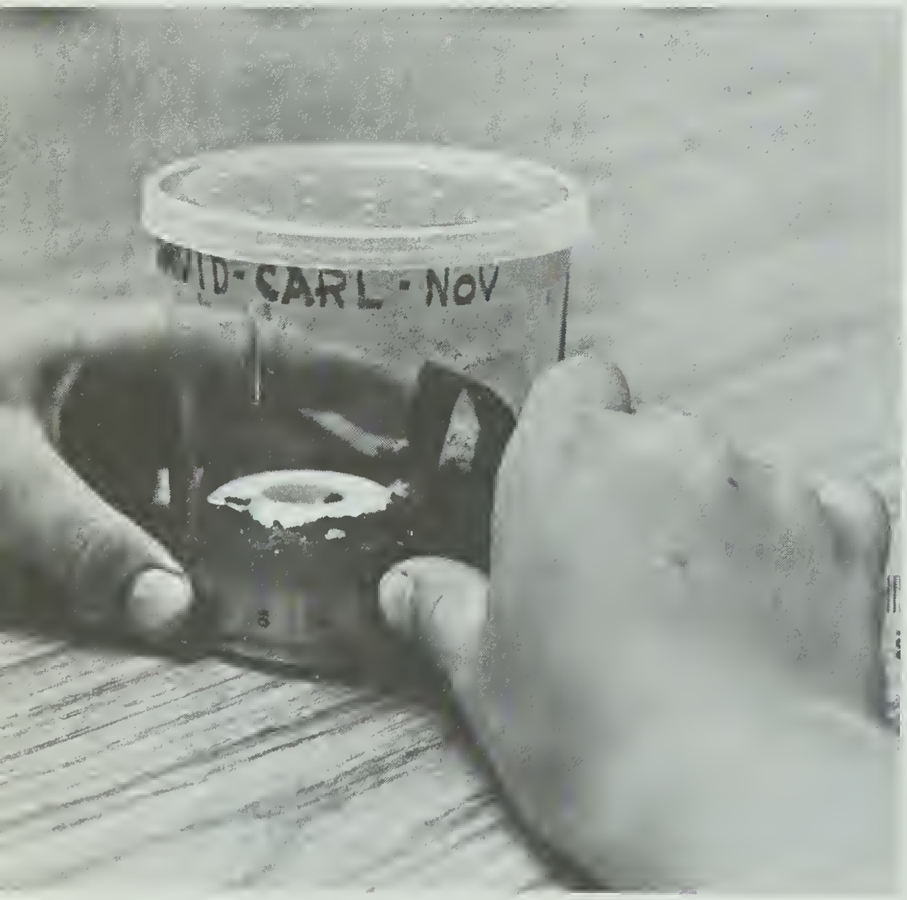
Using student manual page 22. On this page, provision is made for each student to insert the name of the animal she or he would like to measure. The animal selected can be a tadpole, a cricket, or even some other very young (and rapidly growing) animal—such as a puppy, kitten, fish, or human baby. There are two columns for the dates and the lengths. Explain to the children how they can select an animal and measure its length. If a child selects a long animal, you should change the student manual page to read centimeters instead of millimeters.

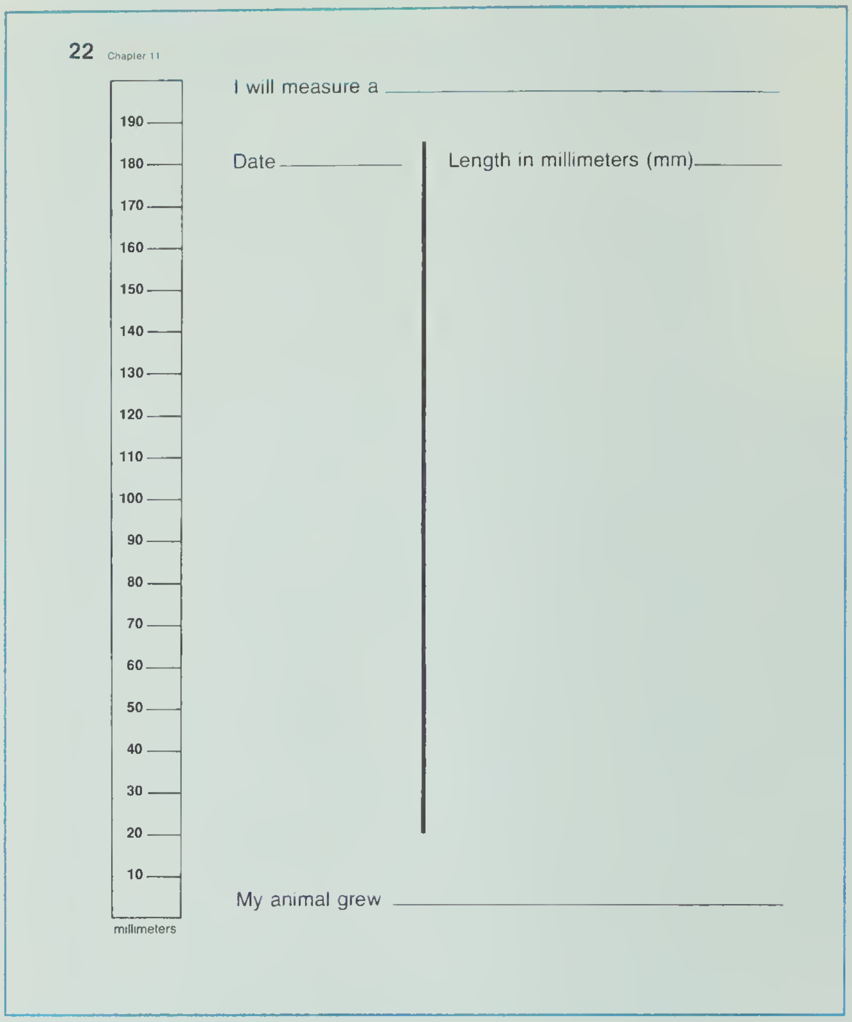
- Do not overemphasize accuracy here. More importantly, the children are to learn the skills of periodic observation, measuring, and recording—and the concept of growth in animals.

For measuring cricket and tadpole lengths, tell the children to place their flexible rulers on the outside of the container when the animal is next to the inside wall and read the length from the ruler (Figure 11-2).

At the bottom of the page, a sentence has been started. It can be the beginning of an oral or written story or be completed simply with a word such as *long*.

Figure 11-2. Measuring the length of a young cricket.




22 Chapter 11

I will measure a ______________________

Date ________ | Length in millimeters (mm) ________

My animal grew ______________________

190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
millimeters

Development and growth in other animals. If the children or anyone else can bring in baby cats, dogs, mice, hamsters, or even humans, your class will benefit from a visit by these growing animals. The children can even record an animal's growth in weight, girth, or height by drawing a new column on student manual page 22.

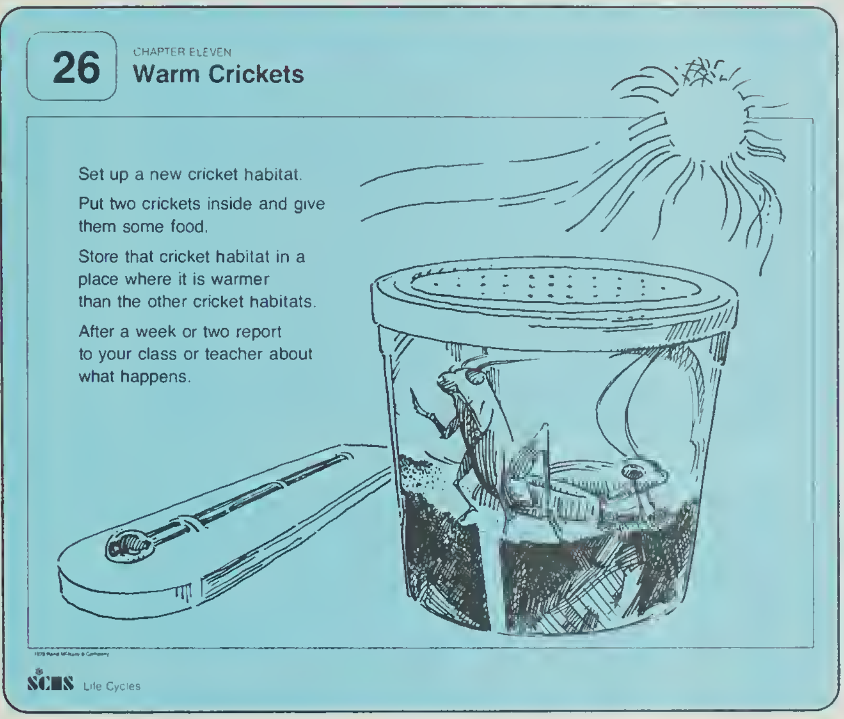
OPTIONAL ACTIVITY

Age and size. Ask several children, of typical heights for their ages, to visit your classroom during one of your science periods. Have your class line up the visitors according to height (you can join the lineup) and then have the visitors tell your class their ages or grades. If there is no definite relationship between height and age, use this as a point of discussion on differences in growth. A natural follow-up to this activity is to invite six or seven adults of any age for the same kind of lineup. This comparison will promote a discussion of the levelling off of growth after a certain age in many kinds of animals.

When you think the children fully understand the idea that animals experience both development and growth, you may terminate the measurements and the activity.

EXTENDING YOUR EXPERIENCE CARDS

26. Warm Crickets. In this experiment, the children compare the effect of increased temperature on the behavior, development, or growth of crickets. The child will need two cricket houses, crickets, soil, and food. Encourage comparison of the crickets *before* one of the containers of crickets is warmed, as well as afterward.



26

CHAPTER ELEVEN

Warm Crickets

Set up a new cricket habitat.

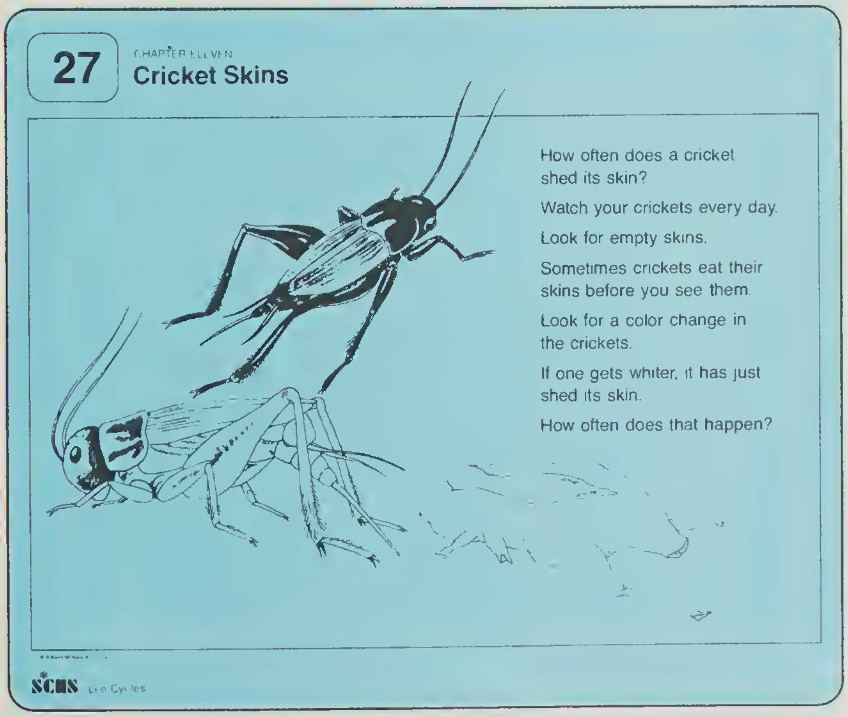
Put two crickets inside and give them some food.

Store that cricket habitat in a place where it is warmer than the other cricket habitats.

After a week or two report to your class or teacher about what happens.

SCIS Life Cycles

27. Cricket Skins. No extra materials or equipment is necessary for this activity, which calls for the children to observe the molting process and its frequency in their crickets. If a student is very interested in this process, give him or her a cricket that has just shed its skin. (It will be white.)



27

CHAPTER ELEVEN

Cricket Skins

How often does a cricket shed its skin?

Watch your crickets every day.

Look for empty skins.

Sometimes crickets eat their skins before you see them.

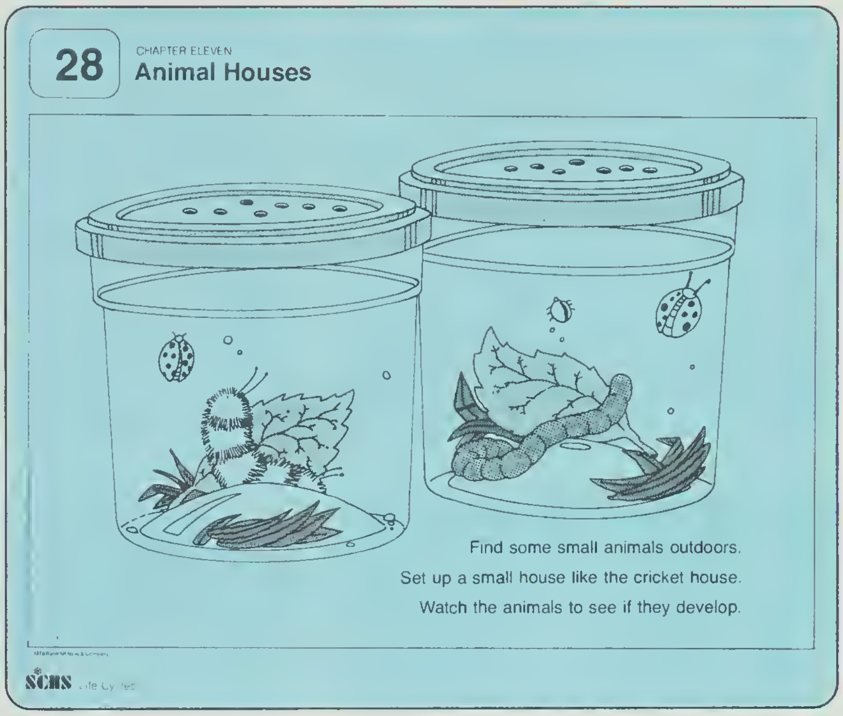
Look for a color change in the crickets.

If one gets whiter, it has just shed its skin.

How often does that happen?

SCIS Life Cycles

28. Animal Houses. The children doing this activity will need some cups, tumblers, or other small containers, such as jam jars, in which to care for their newly found animals. Cheesecloth or other porous tops are much better than airtight jar tops.



28

CHAPTER ELEVEN

Animal Houses

Find some small animals outdoors.

Set up a small house like the cricket house.

Watch the animals to see if they develop.

SCIS Life Cycles

Extending Your Experience cards 1–28 are now available for the children's use. For materials needed, refer to the equipment section at the end of the guide.

Part Four

Metamorphosis

OBJECTIVES

To identify stages in the life cycles of frogs, crickets, fruit flies, moths, mealworms, and local animals.

To arrange in sequential order pictures of stages in the life cycle of a common animal.

To use and apply the term *metamorphosis* correctly.

To understand and use the term *metamorphosis* to refer to the developmental sequence of plants and animals.

BACKGROUND INFORMATION

As an animal develops, it continually undergoes gradual changes. However, humans often notice only the obvious, abrupt changes as an animal hatches, constructs a cocoon, or emerges as an adult. Animals that have such completely different forms at various times of their life cycles are said to undergo complete metamorphosis (change of body shape). And each of the life cycle stages is given its own name.

Some animals go through four distinctly different stages of metamorphosis. Fruit flies, wax moths, butterflies, and mealworms are examples of animals used in this unit that undergo complete metamorphosis. The animal begins as an *egg*, develops into an active, feeding *larva*; becomes a *pupa* that in some cases is surrounded by a cocoon; and emerges as an *adult*. Although apparently passive while it is an egg or a pupa, the animal is using energy during those stages for changing its body form. No activity can be observed externally, but internally much is occurring.

Other animals, such as the frog and cricket, are said to undergo *incomplete* metamorphosis because they

Figure IV-1. Cecropia moth with eggs.

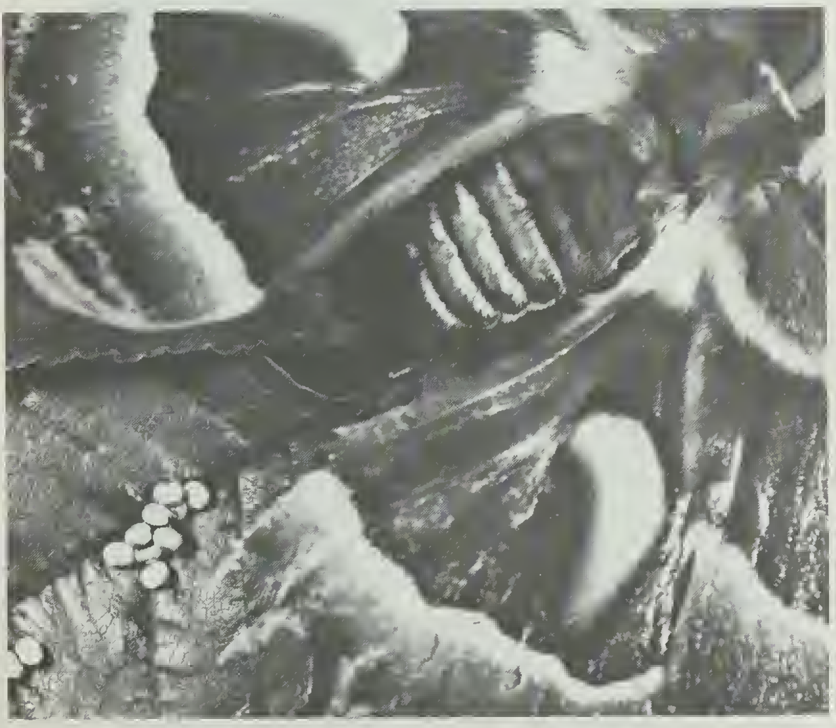
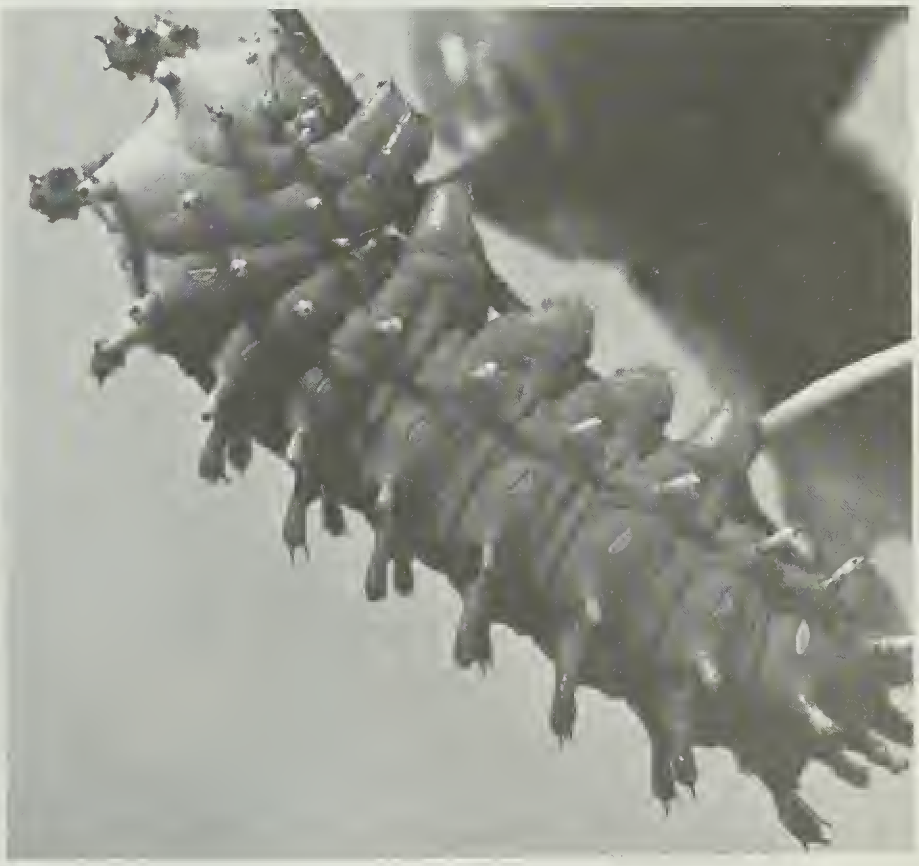


Figure IV-2. Cecropia moth caterpillar (larva).



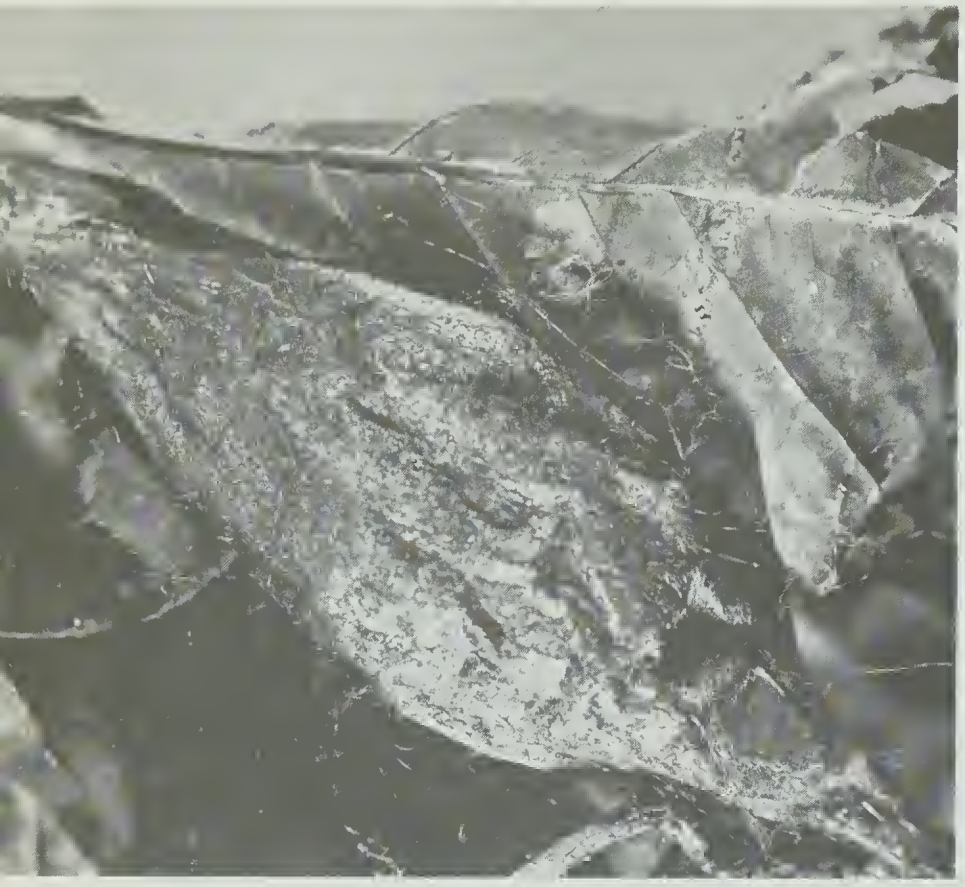
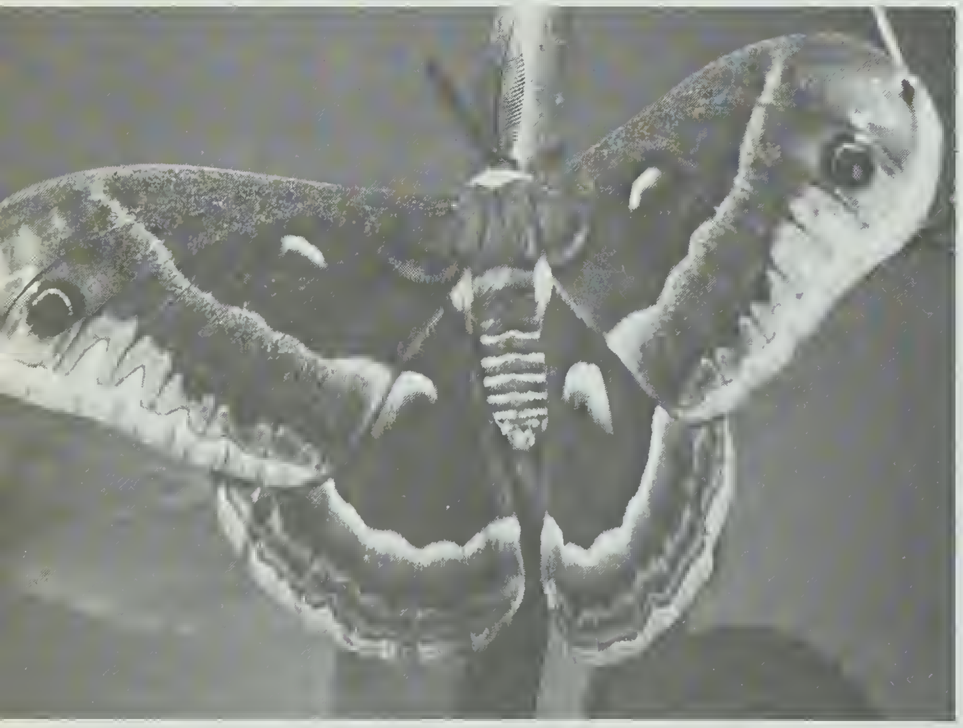


Figure IV-3. Cecropia moth cocoon, containing the pupa.

Figure IV-4. Adult cecropia moth.



show great changes from egg to tadpole or from egg to cricket nymph but appear superficially similar throughout the remainder of their life cycles.

The sequence of changes as an organism develops from a seed to an adult plant or from an egg to an adult animal is called a *life cycle*. All animals and plants have life cycles. However, the changes that occur in any one organism differ greatly from those that occur in others. Humans, dogs, and cats show changes in their body forms which can be considered only slight when compared to those of flies, beetles, and grasshoppers. Yet each kind of organism has a life cycle that will be repeated in every generation.

OVERVIEW

In Chapter 12, "Fruit Flies," the children observe fruit fly colonies and identify the larval, pupal, adult, and egg stages of a life cycle. The concept of metamorphosis is introduced. In Chapter 13, "The Wax Moth," children observe the development of a moth and are introduced to the concept of life cycles. In Chapter 14, "Mealworms," children review six major concepts during their study of mealworm development. The development of butterflies is observed in Chapter 14, "Butterflies." In Chapter 16, "Caterpillars," local animals are observed as they complete their life cycles. In Chapter 17, "Hunting for Life Cycle Stages," other animals in various life cycle stages are found during a field trip. The stages are identified by the children, and the concept of life cycle is reviewed.

GETTING READY

A day or so before you begin Chapter 14, have a few children help you prepare a mealworm culture for each child. (The mealworms are in shipment LC-3). Half fill a petri dish with bran flakes. Then place five large and two smaller mealworm larvae in each dish. Use two small pieces of masking tape to fasten the cover onto the petri dish.

Any mealworms remaining can be used for a classroom culture. Directions are on page 113.

Look around the school area to find a likely source of caterpillars and other stages in insect life cycles for Chapter 16 and 17.

12 Fruit Flies

SYNOPSIS

Children observe the complete development of fruit flies beginning with the larval stage.

Children are introduced to the concept metamorphosis.

Suggested time: ***four class sessions, with additional opportunities for observation later***

TEACHING MATERIALS

For each child:

student manual page 23
scissors*

Drawer 1

Fruit Fly student sheet

For each team of two children:

1 capped vial of fruit flies†

Drawer 2

1 magnifier

Drawer 5

1 label

For the class:

tape*
banana*
glue or paste*
large paper bag*

* provided by the teacher
† in Shipment LC-2

TEACHING SUGGESTIONS

This chapter forms the exploration and invention phases of the *metamorphosis* learning cycle. In addition, Chapters 12 and 13 provide discovery activities for the concept of genetic identity.

Exploring larvae. To each team, distribute one vial containing fruit fly larvae and food. Without mentioning the word *larva*, ask the children if they can see the animals inside the vials. The larvae themselves can be seen without a magnifier, but a magnifier is very helpful for seeing the back and forth movements of the larva's mouth parts as it eats.

Although there may be a delay, some children will see the small white larvae with the rapidly moving "nose." Encourage those who find their animals first to help any others who are having trouble.

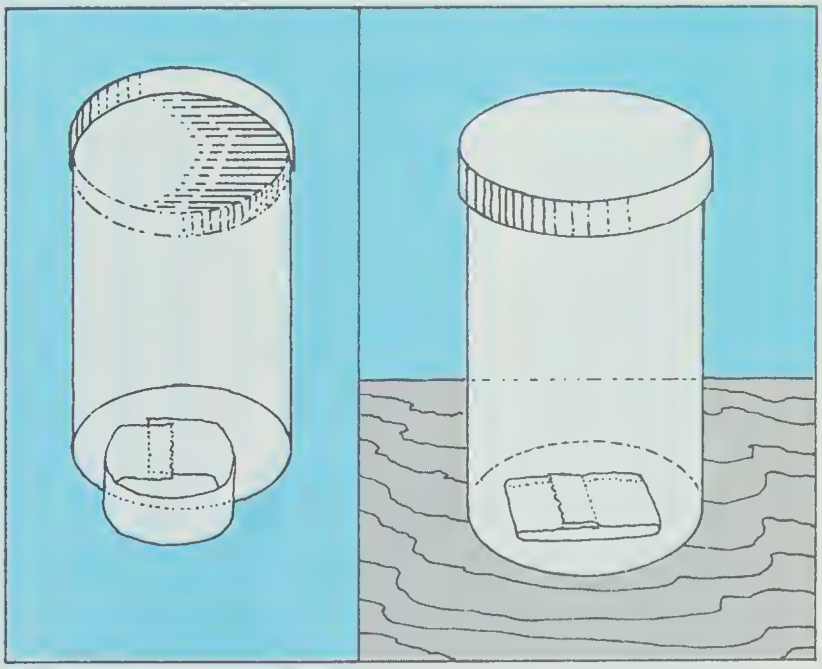
Invite the children to count the number of animals in their vials. This concentrates the children's attention on the animals and their numbers.

When they have completed their counts, have the children use labels to record the number of fruit flies and the children's last names or initials. The best position for a label is just under the snap top on the side of the vial, where it will not hide the larvae.

After the observing and counting, ask the children to describe the animals they saw and how many they think they have. Tell the children they are going to watch the animals become fruit flies.

How can it be a fly? Inquire of the children if they saw any wings on this animal. As they did not, how can it be called a fruit *fly*? A dialogue along this

Figure 12-1. To tape the vials to the desk tops, make a loop of tape (sticky side out). Stick it to the vial bottom and the desk.

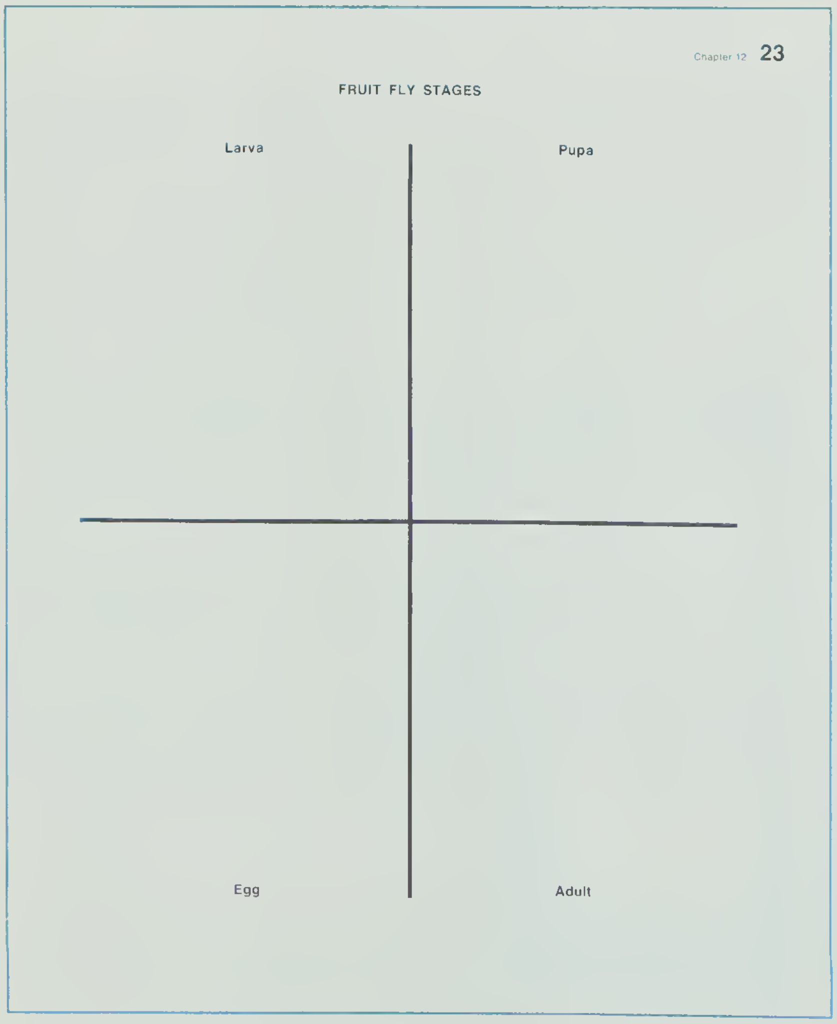


avenue will set the stage for explaining that this worm-like animal is called the fruit fly *larva* (pl. *larvae*). Write the word on the chalkboard and have the children pronounce it aloud.

Storing the vials. The best place for the vials is on or in the students' desks, where the children can observe the continuing development at any time. To tape the vials to the desk tops, make a loop of tape—sticky side out (Figure 12-1). Stick it to the vial bottom and the desk top.

Using student manual page 23. The fruit fly stages are too small to be easily sketched, so give each student a picture of the fruit fly larva to cut out and glue into the student manual. You can tell the students to put this picture under the "Larva" caption or suggest they place it wherever they think it belongs. The latter method will give you feedback about the children's understanding of the relationship between the word *larva* and its picture.

See that the children observe their larvae at least every other day. The larvae grow rapidly, and the children should have the opportunity to see that. Additional food is not necessary, and no other special care is required.


Chapter 12 23

FRUIT FLY STAGES

Larva

Pupa

Egg

Adult

When pupae appear. About five days after the vials of larvae arrive, some or all of the larvae will crawl up the sides of the vials and pupate (Figure 12-2). Each larva will construct a yellow pupa case around its body. This will be attached to the wall of the vial, where it can easily be seen.

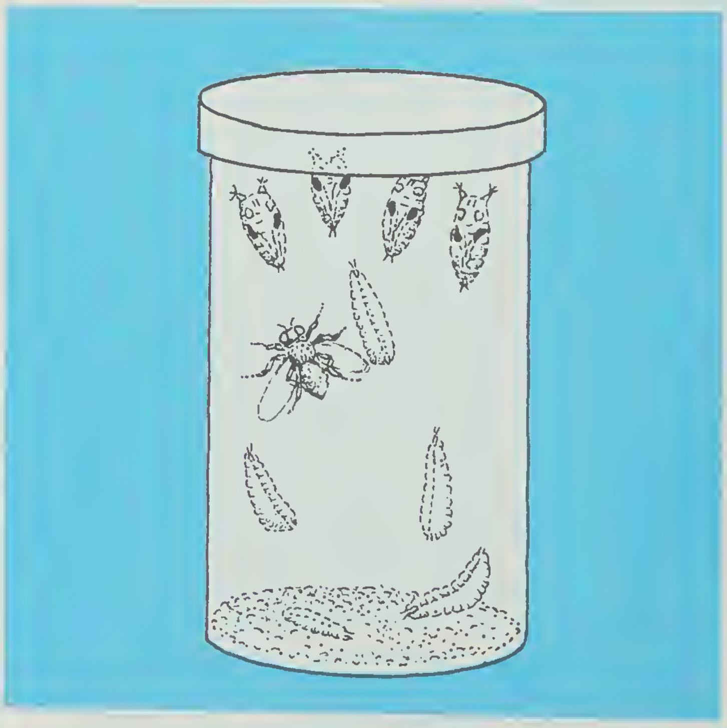
When a larva becomes a pupa, take advantage of the event by arranging for a discussion about what happened, who saw it, how long it took, what the larva did, how big it was, and how long they think it will stay that way.

After the children have shared the experience of seeing a new form of the fruit fly, introduce the term *pupa* (pl., *pupae*) by writing and pronouncing it. You may want to enrich their understanding by encouraging them to make up sentences about the pupa case, how the larva made the pupa case, how the larva got into the pupa case, how the larva will get out, what the pupa looks like, what the pupa is doing in there, and so on. This will not only aid the children's understanding of science but also improve their language skills.

Distribute pictures of the fruit fly pupa and suggest the children trim and glue them in the correct position on student manual page 23.

- There is little for the children to observe in the fruit fly pupa stage, so go on to Chapter 13 now. As the events in that chapter are similar to these, there will be little confusion.
- As you work on Chapter 13, have the children continue watching the fruit fly vials.
- When the adults emerge (in about a week), return to this chapter.

Figure 12-2. Larvae pupating.



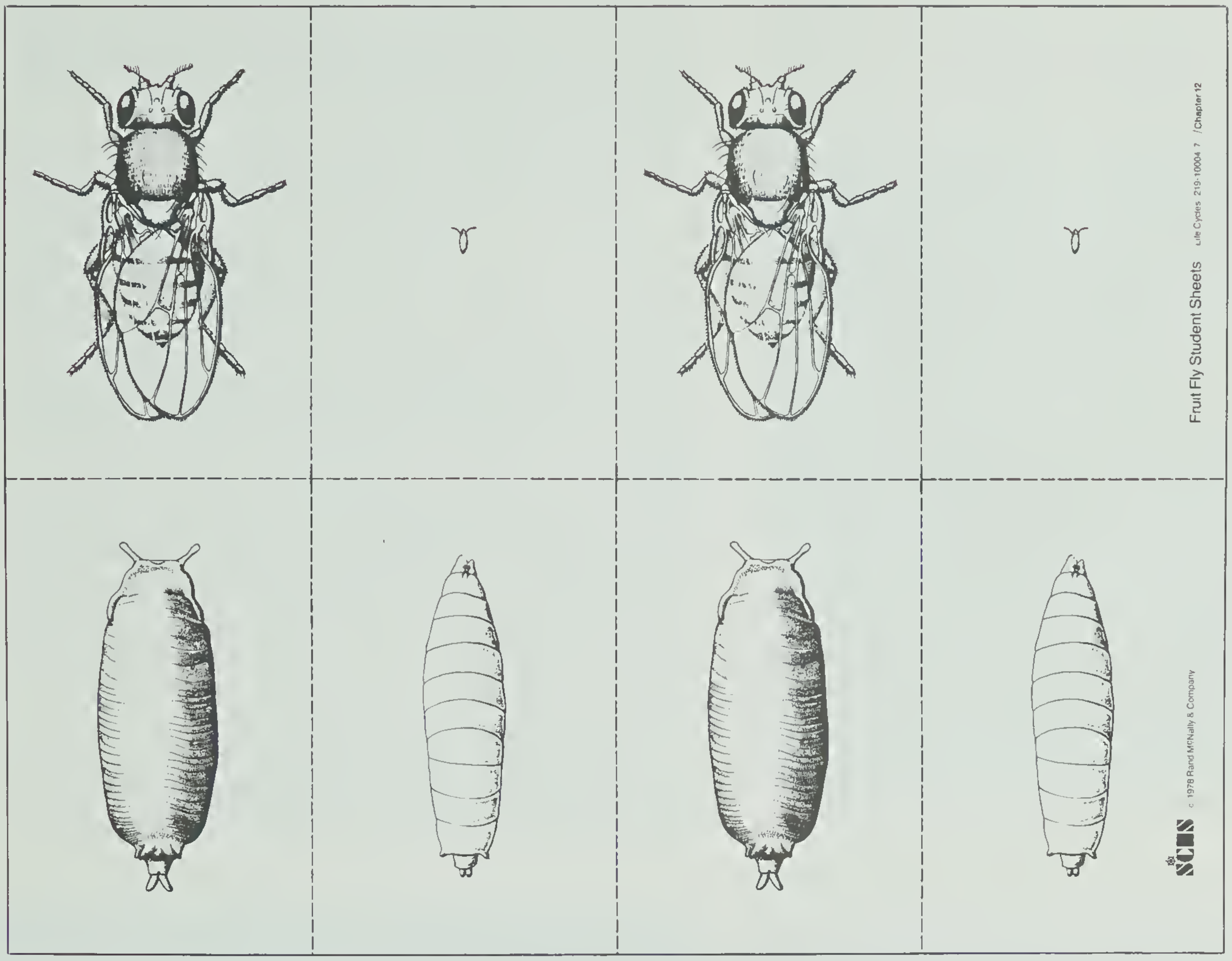

Fruit Fly Student Sheets
Life Cycles 219-10004 7 /Chapter 12
SCIS © 1978 Rand McNally & Company

Figure 12-3. The Fruit Fly student sheet.

Adult flies. About a week after the larvae construct pupa cases, adults can be expected to emerge. Encourage the use of magnifiers and allow plenty of time for observation. Then ask some of the same kinds of discussion questions you used when the pupa cases were made. Did anyone see the flies come out? Can you see how they got out? Are the flies bigger than the pupae? Than the larvae? Does an adult fly look anything like the larva did?

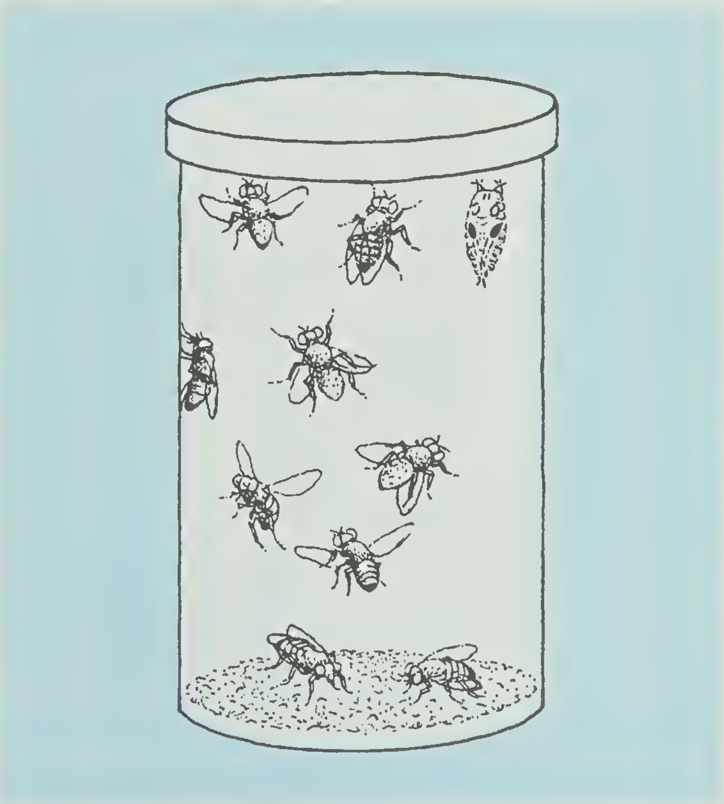
Next ask the children to predict what will happen to the adult flies. They probably know that a human adult stops growing, may have babies, and eventually dies. On the basis of that knowledge, they may predict a similar series of events for the adult fruit flies.

Provide the children with pictures of the adult fly for them to glue into the appropriate section of student manual page 23.

"Inventing" metamorphosis. The changes in the fruit fly from one state to another make up a process that is important and necessary for fruit flies and thousands of other animals.

After the children have seen a larva change into a pupa and the pupa into an adult fly, introduce the

Figure 12-4. Emergence of adult fruit flies.



word *metamorphosis*. One very successful teacher in a trial classroom explained it this way:

> "Animals change as they get older.
> Do you remember the frog eggs?
> How did they change?
> And the cricket eggs?
> And the fruit fly larvae?
> There is a word which means changing shape.
> The word is *metamorphosis*.
> (The teacher writes the word on the board.)
> Can you say that great big word?
> What did the pupa change into?
> Yes, and what do you call that change?
> I saw a butterfly larva change into a pupa once. What would you call that change?
> What if that pupa then changed into a butterfly?
> Do you know of metamorphosis in any other animal?"

Within the next two days, the adult females will deposit eggs on the inside walls of the vials. These eggs are quite small, white, and have a little antennalike structure at one end. Fruit fly eggs can be seen by the unaided eye, but a magnifier is very useful. Provide magnifiers for the children and encourage them to look for eggs. Tell them the eggs are small and usually can best be observed on the side of the vial—not in the food.

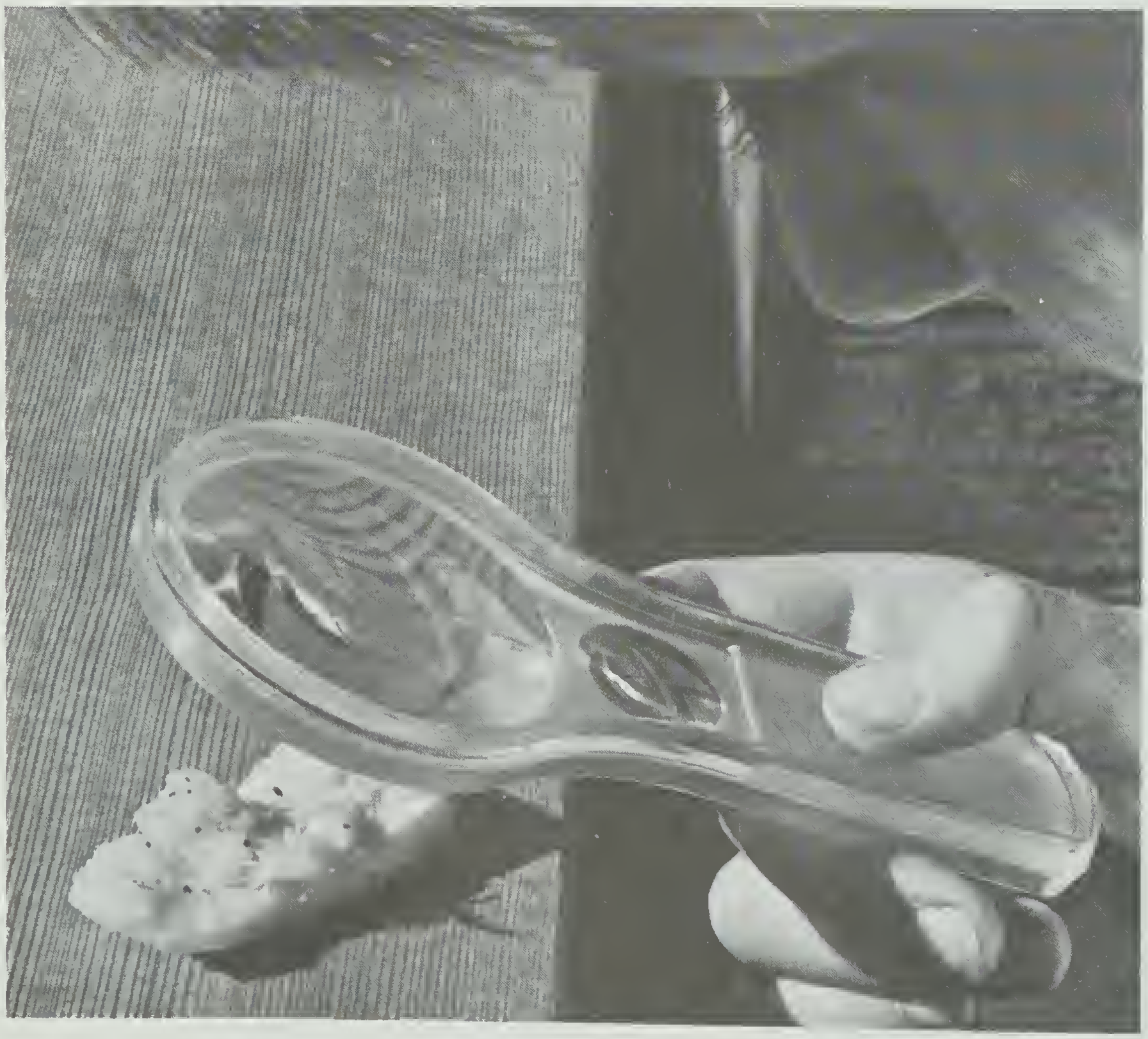
After the children have seen eggs in their own vials or in others', write the word egg on the board. Review what they have learned about eggs and remind the youngsters of the cricket and frog eggs they saw earlier. You might emphasize that eggs are made by adult animals, as the students have now seen with the adult fruit flies.

Provide the children with the pictures of fruit fly eggs so they can complete page 23 in their student manuals.

Continuing the observations. The fruit flies may have enough food remaining to go through another complete life cycle. If there appears to be insufficient food, small pieces of banana can be added to the vials. Cool the vials to about 10°C (50°F) for a short time to slow down the flies before opening the vials and adding the food.

During the development of this second generation of flies, beginning this time with the eggs, the students may measure how many days each stage lasts.

Figure 12–5. A fruit fly egg is difficult to see.



Cleanup. Decide whether to have your students do the optional activity before cleaning up.

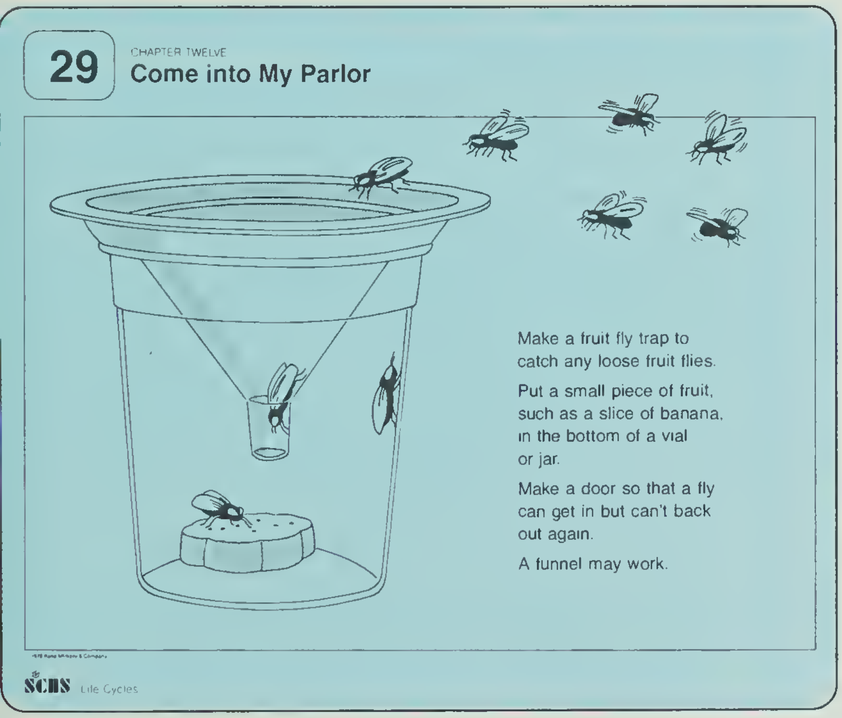
Collect the fruit fly vials in a bag and return them to the resource center if your school has one. Otherwise, put them in any freezer for twenty-four hours. Then either discard the vials or wash them out and save them.

OPTIONAL ACTIVITY

Fruit flies eating fruit. Scar an apple or other fruit and place it in a large plastic bag. Add three crumpled paper towels, lay the bag on its side, and insert a vial containing flies. Put your hand inside the bag and have one student squeeze the bag around your wrist to prevent the flies from escaping as you uncap the vial. Carefully withdraw your hand, the vial, and the cap. Seal the bag and hang it out of direct light where the children can see the life cycles of fruit flies on their normal food.

EXTENDING YOUR EXPERIENCE CARDS

29. Come into My Parlor. The student will need a jar, some fresh fruit, and whatever he or she decides to use for a trap.



29

CHAPTER TWELVE

Come into My Parlor

Make a fruit fly trap to catch any loose fruit flies.

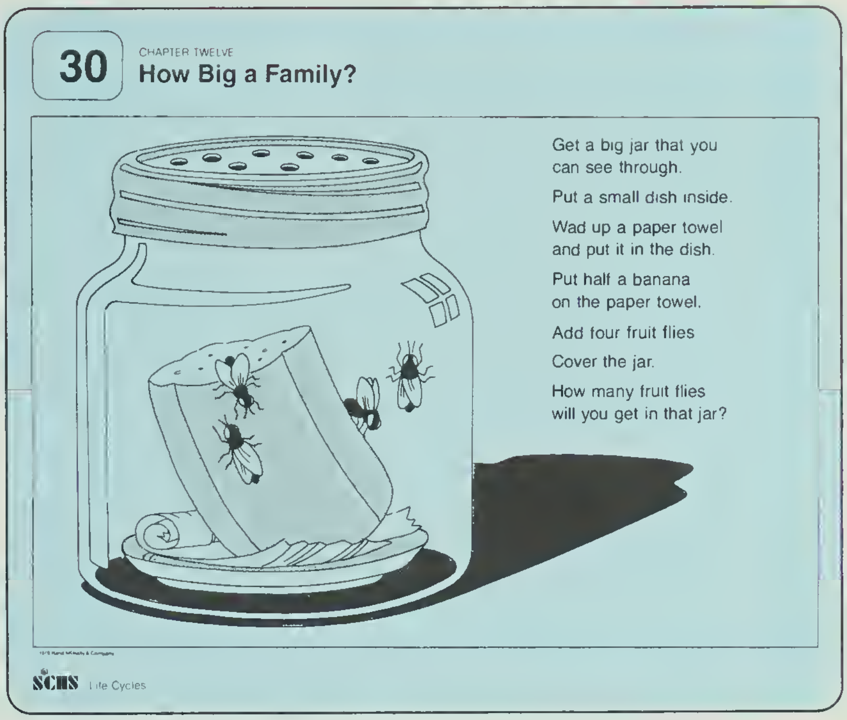
Put a small piece of fruit, such as a slice of banana, in the bottom of a vial or jar.

Make a door so that a fly can get in but can't back out again.

A funnel may work.

SCIIS Life Cycles

30. How Big a Family? The child will need a mayonnaise or other large covered jar, a small dish, a paper towel, six fruit flies, and a banana.



30

CHAPTER TWELVE

How Big a Family?

Get a big jar that you can see through.

Put a small dish inside.

Wad up a paper towel and put it in the dish.

Put half a banana on the paper towel.

Add four fruit flies

Cover the jar.

How many fruit flies will you get in that jar?

SCIIS Life Cycles

13 Wax Moths

SYNOPSIS

Children observe the complete life cycle of the wax moth.
The term life cycle is invented.

Suggested time: *four class sessions to set up, followed by several weeks' observation time*

TEACHING MATERIALS

For each child:

student manual page 24

For each team of four children:

Drawer 1

1 set Life Cycle cards

Drawer 2

1 magnifier
1 tray

Drawer 4

2 small fluted containers

Drawer 5

1 label

For the class:

wax moth larvae†
larva food†
small, sharp-pointed scissors*
wheel (such as a bicycle wheel)*
tape*

Drawer 1

Moth Development cards

Drawer 2

1 light source

Drawer 4

5 or 6 small fluted containers

Drawer 5

wooden sticks

* provided by the teacher
† in Shipment LC-2

CAUTION
These organisms will not damage clothing, but they are agricultural pests. Do not release any living wax moths.

ADVANCE PREPARATION

When you receive the wax moth larvae in shipment LC-2, break the packet into several subsections and place each in a fluted container. These containers will serve both as demonstration displays and as distribution containers.

Set up three distribution stations with these fluted containers and larvae, tape, wooden sticks, and magnifiers at each station.

TEACHING SUGGESTIONS

Invention of *life cycle* occurs at last. This chapter also serves to provide the discovery phase of the *metamorphosis* learning cycle.

Setting up moth farms. Gather the children close to you and tell them they will now watch another organism develop and grow. Identify and show them some of the wax moth larvae. These are golden, worm-like animals that can be found crawling through the food in which they are shipped.

Set up a moth farm as a demonstration for the children:

- Invert one fluted container over another.
- Cut a piece of tape about 10 centimeters long.
- Form a long hinge between the two containers by taping the edges together.
- Open and close the container to illustrate the hinge.
- Using your hands, scissors, or 2 wooden sticks, divide one of the food balls containing larvae into two equal pieces.
- Put one of those halves in the container.
- Close the lid and tape all of the edges. Make some pinholes in the lid for ventilation.
- Write your name and the date on a label.
- Put the label on the lid.

Have each team prepare a similar moth farm, using the materials from the distribution station.

Observing the larvae. While each team is constructing a moth farm, provide ample time for the children to search for the larvae in the food, using the wooden sticks provided or their fingers. Encourage the use of magnifiers.

The children will be able to see the larvae moving, pushing their mouth parts to and fro, and eating. Some children will just gaze, but others may find the larva's head and tail, comment on the amount of activity, and note where the larvae congregate. Children who get their larvae to crawl on popsicle sticks may see a larva "spin a thread" as it falls from the stick. The larva is supported by that thin secretion.

The larvae crawl around a great deal and may not be evenly distributed in the sections of food you pre-

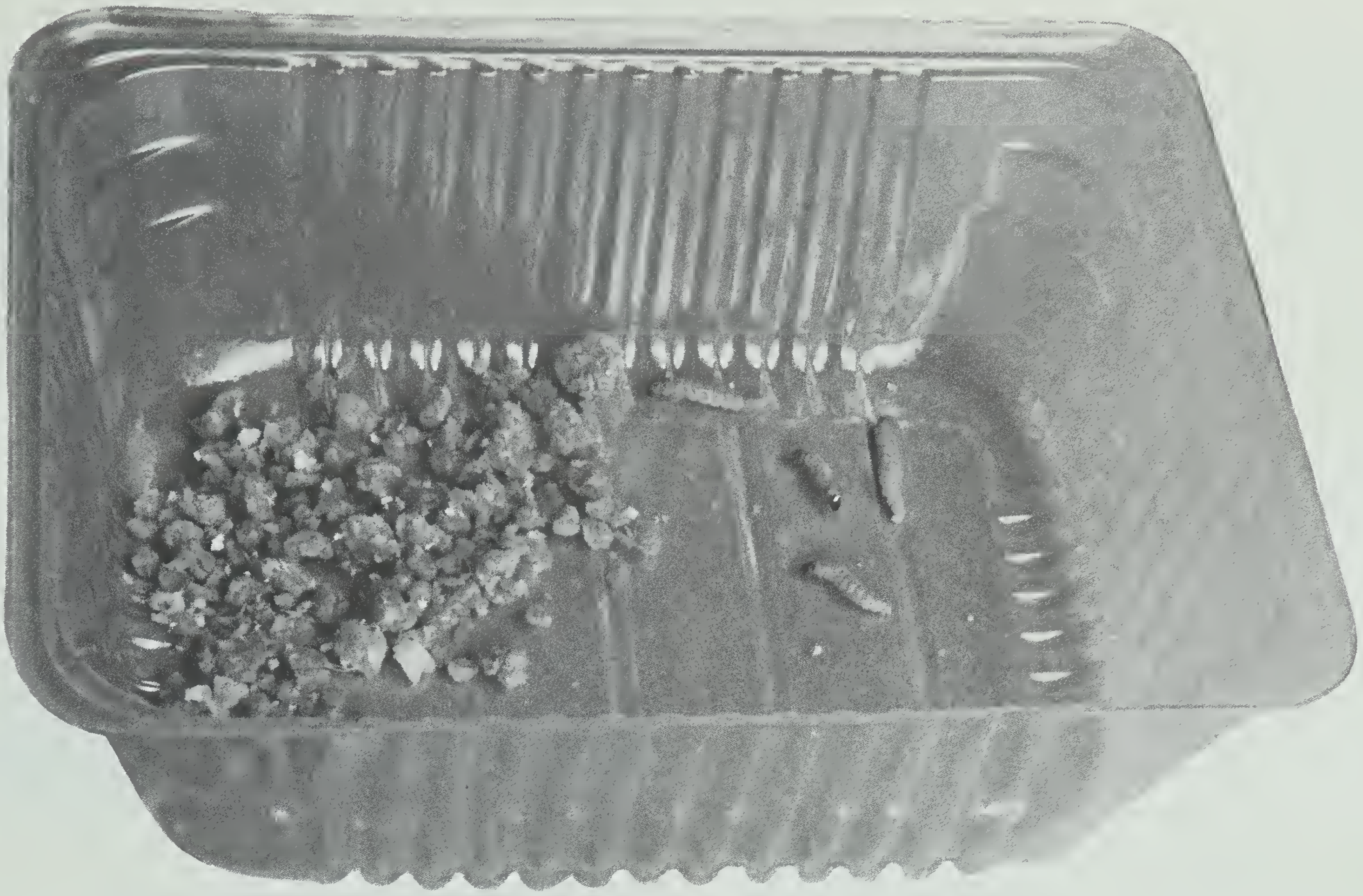


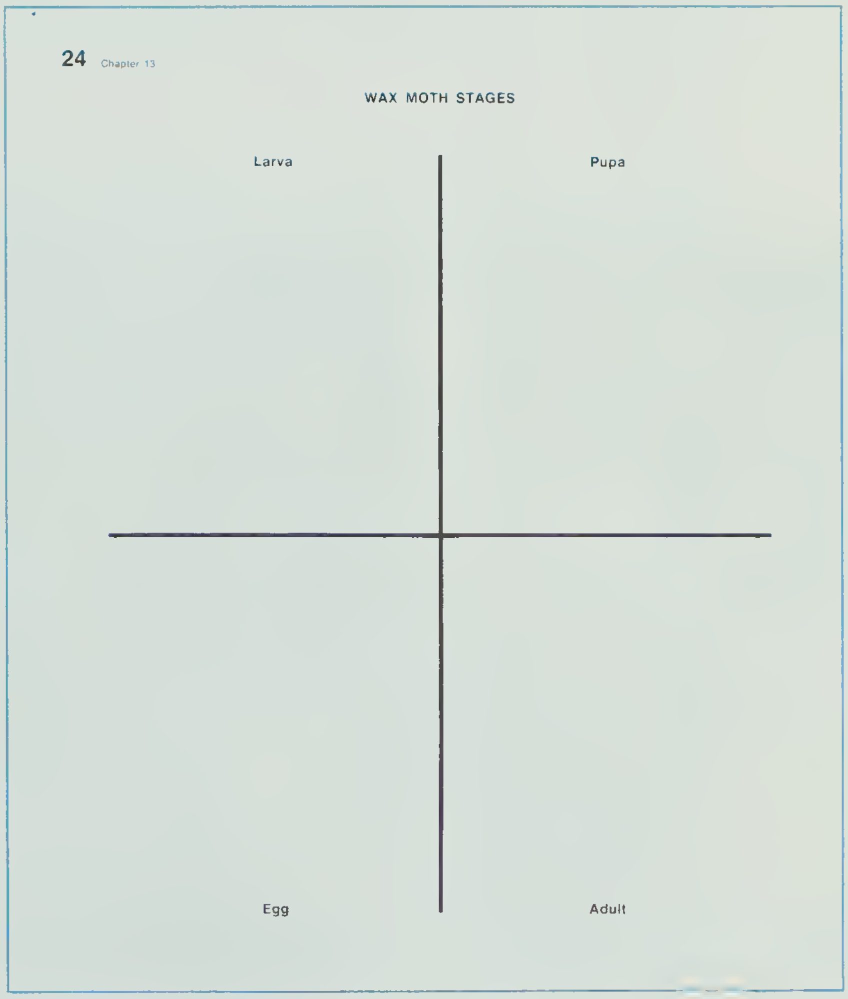
Figure 13-1. Wax moth larvae.

pared. If any team has fewer than five larvae, let them get some from the original shipment or from other teams.

Using student manual page 24. The four stages of the moth's life cycle are named on this page. As metamorphosis occurs, ask the students to draw each stage. Begin with the larva, which the students just observed.

Maintaining the larvae. Explain to the children that they will keep these moth larvae in a warm place. Select such a place in your room, or place the moth farms under the light source. Adjust the height of the light source so that the temperature is between 24 and 30°C (71 and 86°F).

During the next few science periods, the children should observe both the fruit flies and the moths. During one of these periods, explain to the children that the larvae may crawl into a small space if one is available. Using your demonstrator moth farm, show the children how to create small spaces by placing a 7-cm piece of tape across the flutes on the bottom container. Do not press the tape into the flutes, but let it bridge the spaces. Don't tell the children now, but the larvae will probably construct their cocoons between the tape and the container, making the cocoons very visible. Later the tape containing the cocoons can be stripped off for observation.



24 Chapter 13

WAX MOTH STAGES

Larva	Pupa
Egg	Adult

Growth of the larvae. The moth larvae grow quite rapidly. The children may notice that the larvae eat all the time. This gives you a chance to see if the children use the proper term, *growth* instead of *development*.

As the larva grows, its features become more obvious. The mouth parts can be observed chewing, internal organs can be seen through the skin, and even little bristles on the body can be seen. When the larva is about 2 cm long, ridges or folds will appear along its sides. When that happens, the larva is nearly ready to construct its cocoon. Metamorphosis is occurring—the body shape is changing into a pupa.

Encourage the children to share their observations with each other.

Moth pupae. When the moth pupates, the children will be able to see the construction of the cocoon (Figure 13-8). This will provide you with ample opportunities to encourage discussions and descriptions leading to language development.

Invite the students to draw the pupa under the appropriate heading on student manual page 24.

Opening a cocoon. There may be some confusion between *pupa* and *cocoon*. To help clear up the matter, you can open a cocoon or two for the children so they can see the pupa inside. Wait one week after the cocoon is completed before opening it. This will establish that the larva wove a protective web (cocoon) around itself before it completed its metamorphosis into a pupa.

The surgery is clean and easy. Using a pair of small, sharp sewing scissors, slip one point into the open end of a cocoon. Then, as if you were cutting a bandage from an arm, cut along the cocoon until it has been laid open. By keeping the inside scissors tip tilted slightly upward, you should easily miss cutting the pupa (Figure 13-2).

Now you can lift out the pupa for the children to see. When the pupa is touched, it is likely to move, indicating that the animal is alive.

- Begin Chapter 14 now, while you are waiting for the wax moths to emerge.

Emergence of the moths. About thirteen days (depending on the temperature) after the larva became a pupa, the adult moth will emerge from the cocoon. Inside the cocoon, the moth will have left its pupa skin. There will be some excitement when the adult moths are discovered. The moths do not fly very well, so you may let the children *slowly* open the lids to get a better look at them. As soon as the children have examined the adult moths, ask them to close and tape the lids. Mating and egg laying must occur *inside* the farm so that none of the animals will be freed.

Adults laying eggs. The adults will mate and lay more eggs, a phenomenon you may wish to have your children observe. Adult moths often lay their eggs at the junction of the two fluted containers. The children will probably notice the eggs first if you show them where to watch for them over the next week or so (Figure 13-4).

Figure 13-2. Opening a cocoon.

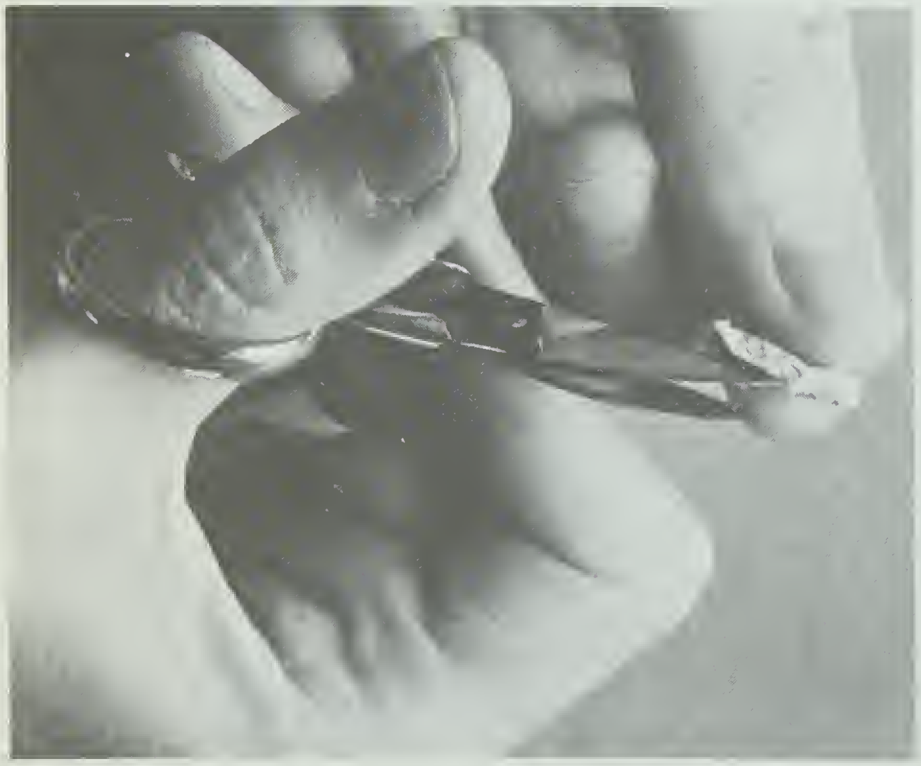
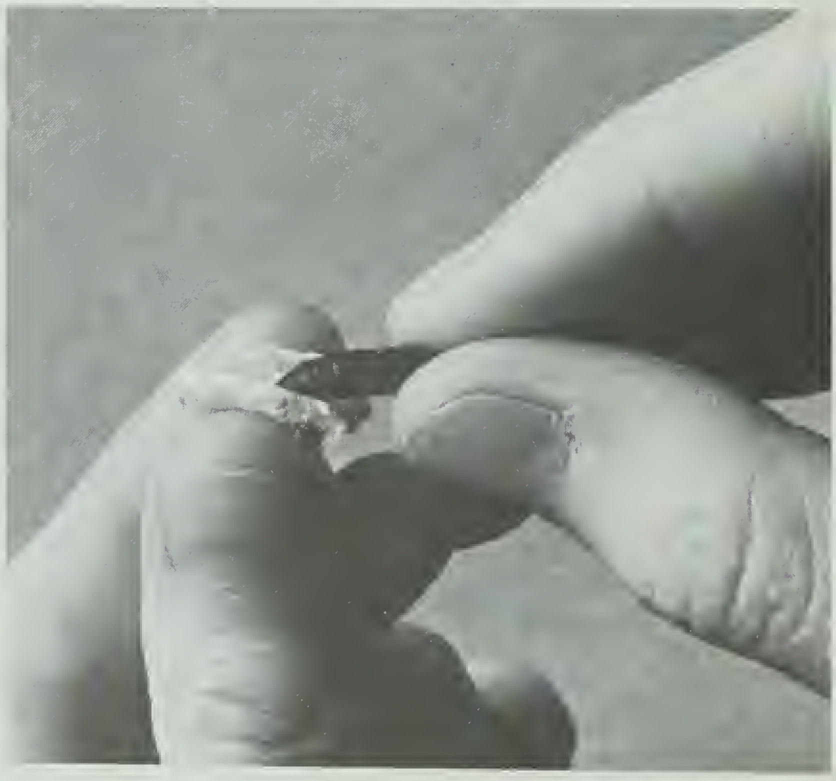


Figure 13-3. Removing the pupa from the cocoon.



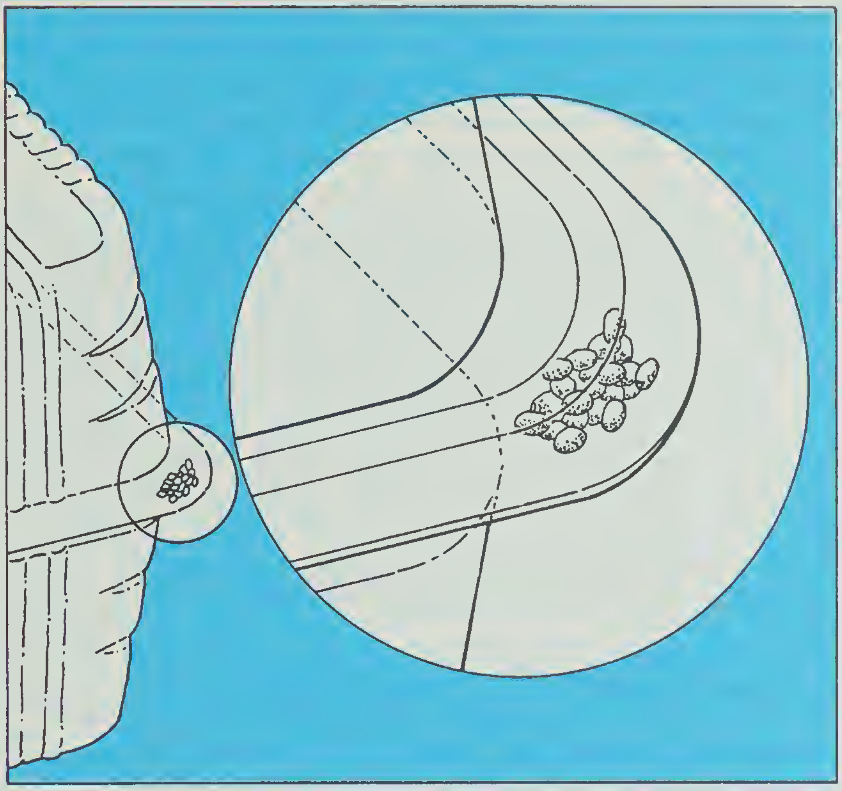


Figure 13-4. Moth eggs laid on a fluted container.

After laying eggs, the moths will die. Thus, the cycle has been completed: egg to larva to pupa to adult to egg again.

Dead moths may be removed or left in the moth farm.

Review discussion. Review wax moth development by allowing team members to describe the events in their moth farm. Concepts to listen for include larva, pupa, adult, metamorphosis, development, and growth.

After eggs have been deposited or when tiny larvae appear, proceed to the invention of life cycle.

"Inventing" life cycle. Use the large Moth Development cards to help introduce this concept.

Using a ring of tape—sticky side out—attach the Larva card somewhere near the upper center of the chalkboard. Then show the children the Pupa card and ask if the pupa appeared before or after the larva. Position this card next to the Larva card.

Display the Adult card and let the children suggest how you should position it. If they suggest it should be placed next to the Larva card, see why they think that is so. Position the Adult card in the next available clockwise position. Display the Egg card, ask which one of the moth stages made the eggs, and position that card between the Adult and Larva cards.

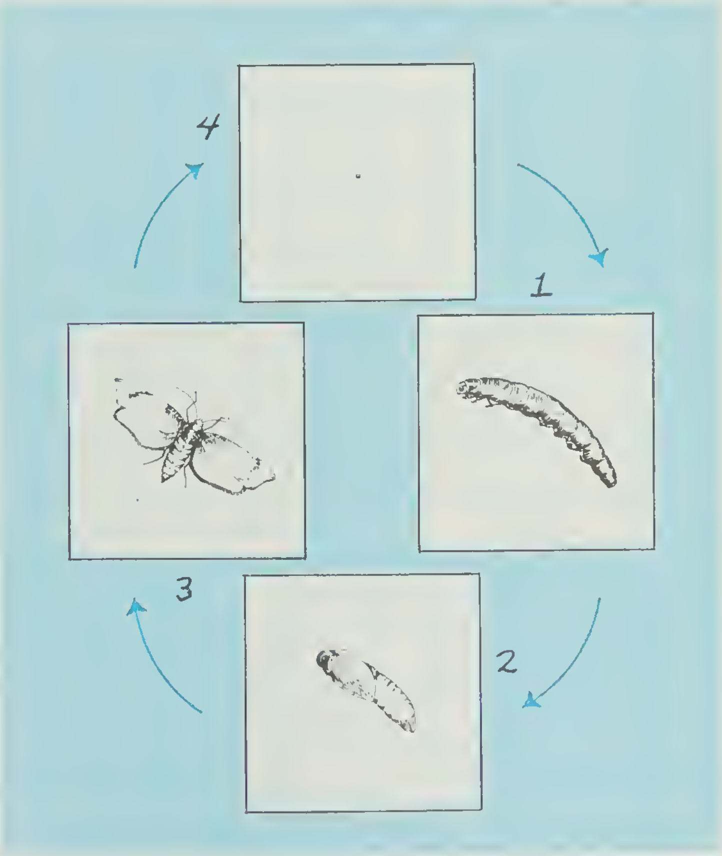
Now ask the class to tell you which stage of the moth they saw first and put the numeral 1 by the larva. Do the same thing for the pupa, adult, and egg stages, by placing the numerals 2, 3, and 4 next to them.

Tell the children you will draw arrows from one stage to another. Let them tell you where you should draw the first arrow, then where you should draw the second. Continue adding arrows until your drawing appears like the one in Figure 13-5. Draw curved arrows, so that when all arrows are in place the drawing will resemble a circle.

Tell the children that this drawing shows the *life cycle* of the moth. Have them say the words and tell them it is called a life cycle because it shows how life goes from egg to larva to pupa to adult and back to egg again, just as a mark on a revolving tri-*cycle* or bi-*cycle* wheel comes back to the place where it started. A demonstration of how a chalk mark on a revolving bicycle tire always comes back to the top may enhance the children's understanding of the word *cycle*.

Using the Life Cycle cards. Remove the cards from the chalkboard and obtain the Life Cycle cards from the kit. Give one set of cards to each team of four. Tell the children to turn all the cards so they are picture side up. Then ask them to arrange the cards to show the life cycle of the moth. As you visit each team, look to see if students have the cards in the correct order and if the cards form a circle. If a team has done that properly, you might ask it to rotate the whole cycle partway, keeping each card in its proper relation to the other cards. Ask if this arrangement still shows a

Figure 13-5. "Inventing" the life cycle concept.



life cycle. Ask the children to rotate it even more, and repeat the question. Encourage them to continue rotating the cards.

When the students indicate their understanding of the life cycle concept by their ability to rearrange the illustrations, have them turn the cards over, so that only the printed terms can be seen, and arrange the terms as they did the illustrations.

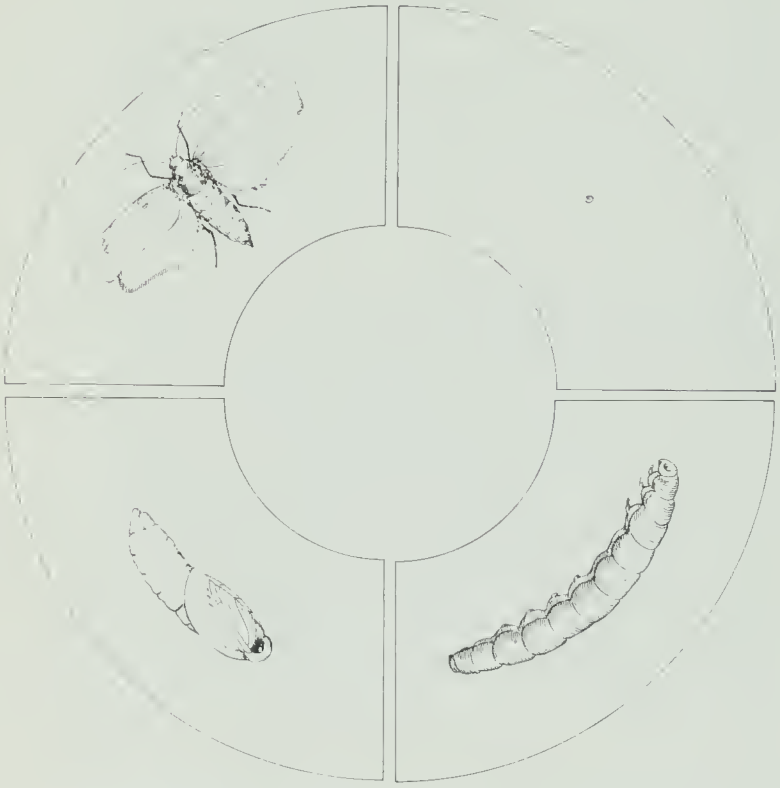
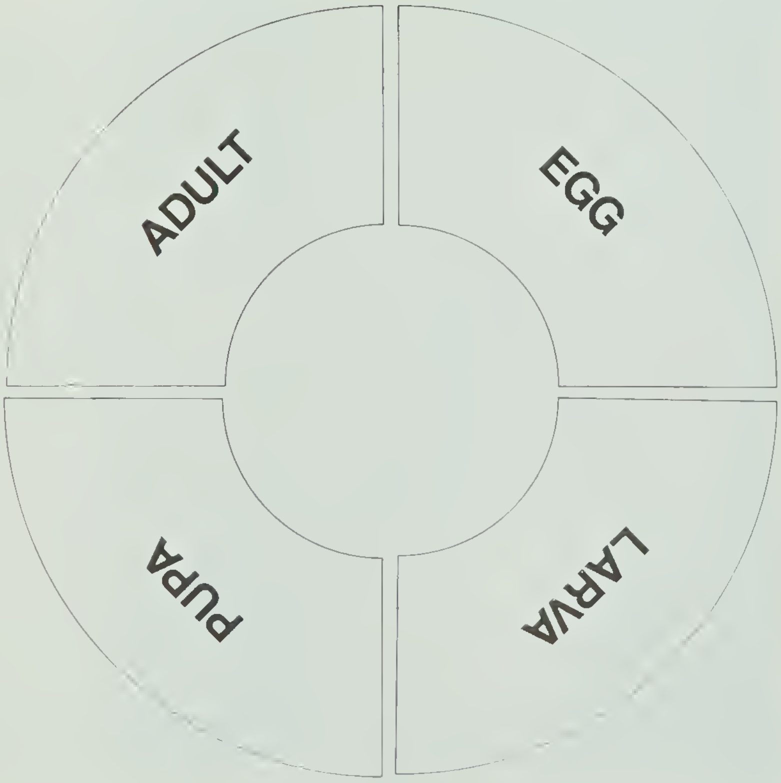


Figure 13–6. The Life Cycle cards.



What to do with the organisms. This life cycle will continue in the classroom if more food is made available. You may order food or make it according to the directions in the appendix. But you must not release these animals into the environment alive. If your school district has an organism resource center, combine all the life cycle stages of the wax moth in a plastic bag and return the bag to the resource center.

If you do not have a place to send the animals, place the sealed bag in a freezer for three days, then discard it in any trash can.

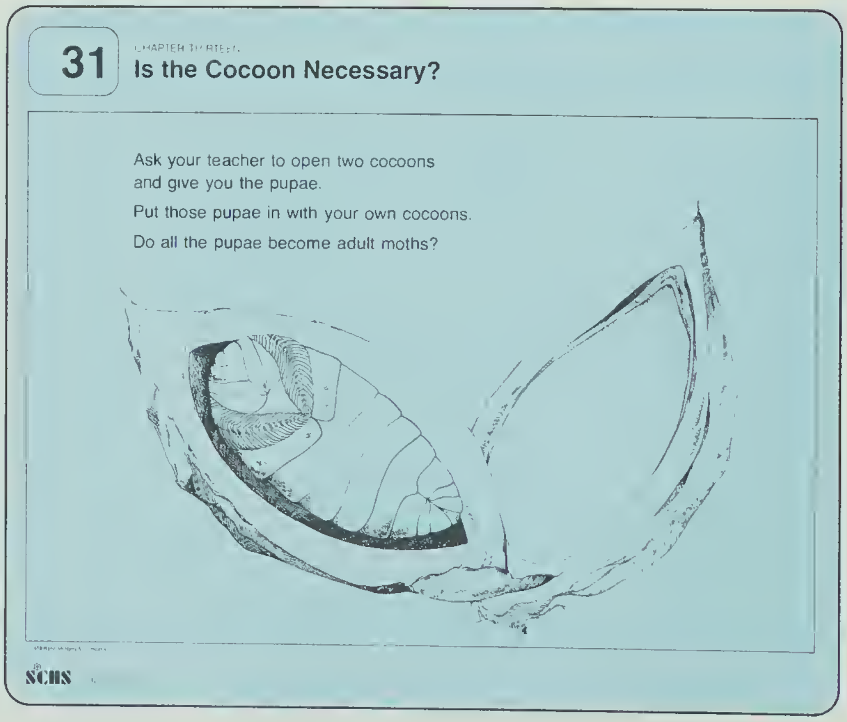
Cleanup. Remove the labels first. Then wash all containers in plain water. Soap and detergent residues may harm the next batch of organisms, so do not use them. Air dry all containers and return them to the proper kit drawers for future use.

OPTIONAL ACTIVITY

Finding pupae outdoors. Encourage the children to look for more cocoons outdoors and to bring them in for study or for emergence.

EXTENDING YOUR EXPERIENCE CARDS

31. Is the Cocoon Necessary? No special materials are necessary, although you will have to provide a couple of pupae. (A cecropia is shown here and on card 32.) In classroom tryouts, we have had good experiences with having the children open cocoons and remove the pupae themselves; if you are not pressed for time, you might let them try it.



31 CHAPTER THIRTEEN

Is the Cocoon Necessary?

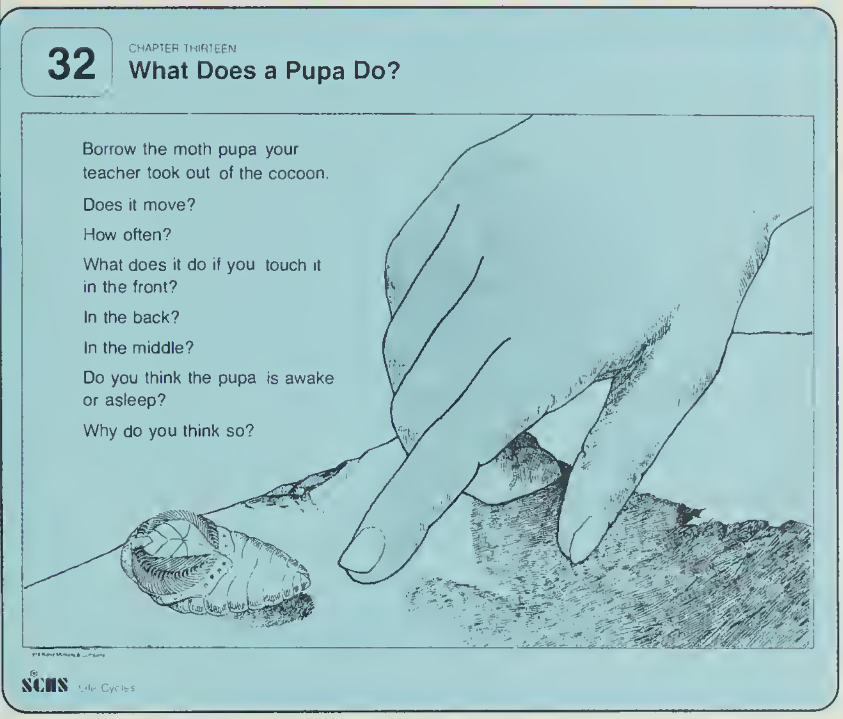
Ask your teacher to open two cocoons and give you the pupae.

Put those pupae in with your own cocoons.

Do all the pupae become adult moths?

SCHS

32. What Does a Pupa Do? You will need to provide the pupil with one or two live pupae. These pupae may be reused by other students doing this activity. You may want to have the child open the cocoon and remove the pupa.



32

CHAPTER THIRTEEN

What Does a Pupa Do?

Borrow the moth pupa your teacher took out of the cocoon.

Does it move?

How often?

What does it do if you touch it in the front?

In the back?

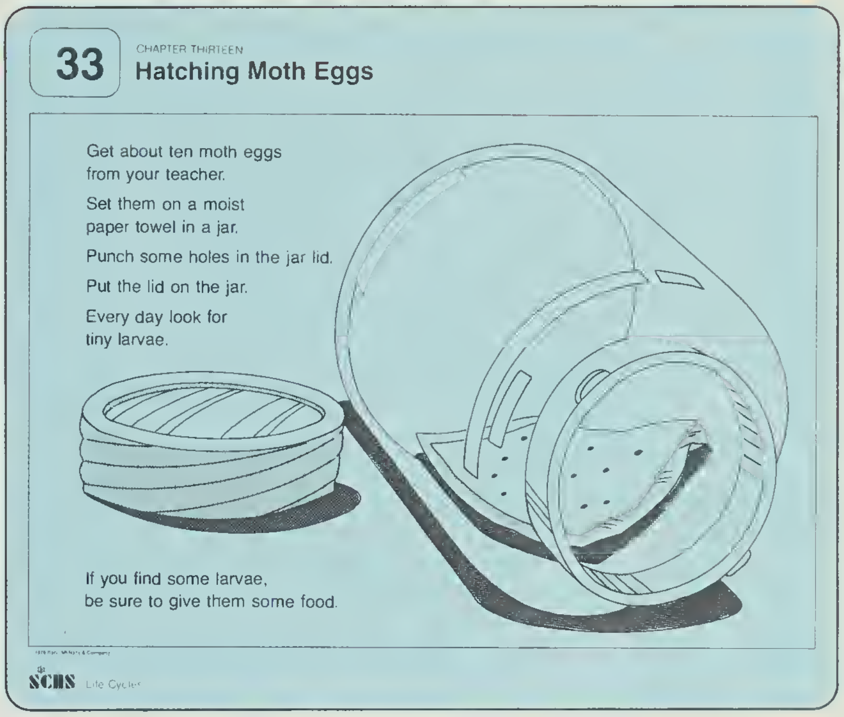
In the middle?

Do you think the pupa is awake or asleep?

Why do you think so?

SCIIS Life Cycles

33. Hatching Moth Eggs. The children will need moth eggs to carry out this investigation. Look for moth eggs at the junctions of the two fluted containers. They are usually laid in narrow or tight spaces. They are nearly impossible to find in the food, so don't even try looking there. When you have found some eggs, carefully bend off a few with your fingernails, tweezers, or even two toothpicks pinched together.



33

CHAPTER THIRTEEN

Hatching Moth Eggs

Get about ten moth eggs from your teacher.

Set them on a moist paper towel in a jar.

Punch some holes in the jar lid.

Put the lid on the jar.

Every day look for tiny larvae.

If you find some larvae, be sure to give them some food.

SCIIS Life Cycles

14 Mealworms

SYNOPSIS

Children observe the growth and development of mealworms.

Suggested time: ***one session, followed by short, informal observations over several weeks***

TEACHING MATERIALS

For each child:

student manual pages 25–27
5 large mealworm larvae†
2 small mealworm larvae†

Drawer 3

1 petri dish with cover

Drawer 5

1 label

For the class:

1 package mealworm food†
1 bottle red fingernail polish*
knife*
masking tape*
potato*

Drawer 2

16 trays
16 magnifiers

* provided by the teacher
† in Shipment LC-3

ADVANCE PREPARATION

You should have prepared individual cultures of mealworms for each child before beginning this activity. Directions are on page 64.

TEACHING SUGGESTIONS

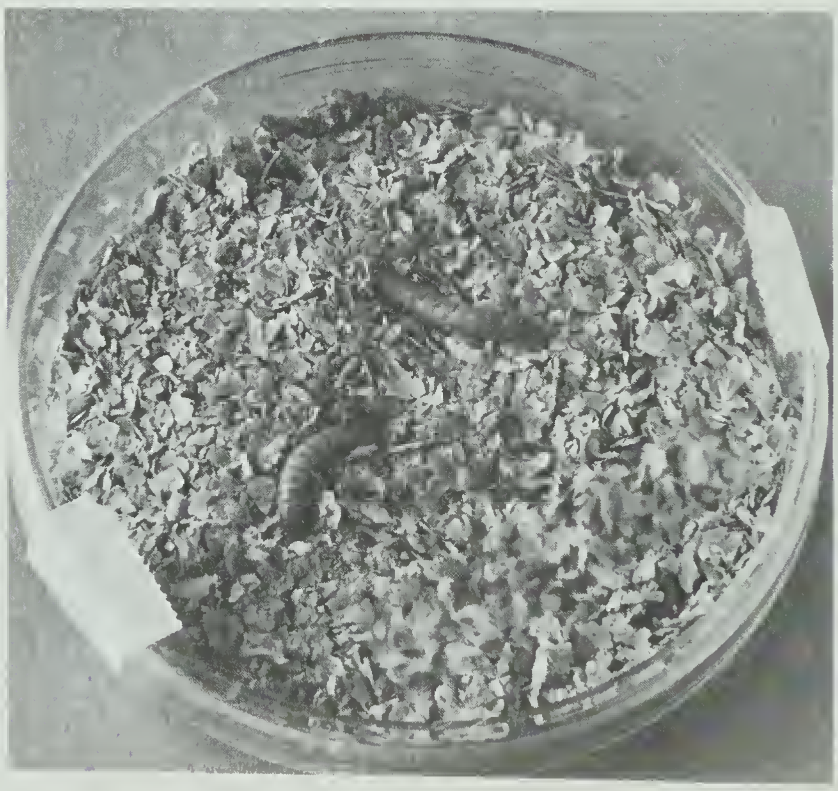
The work with mealworms provides discovery phases of learning cycles that include the concepts *life cycle* and *metamorphosis*.

Introducing the mealworms. Give each child a mealworm culture, to be labeled with his or her name. Ask the children to loosen the tape, lift the cover, and observe the contents. (Warn them not to eat any cereal.) You may see some surprised children as they discover "worms in the cereal!" Tell them these animals are called mealworms and that they can be taken out of the dish for inspection. Have one student distribute the magnifiers and trays.

Allow each child time to observe the mealworms crawl on desks or hands. If some students do not want to touch the mealworms, let them respond in their own way. When they see others handling the mealworms without fear, they too will try it.

During this introductory period, children usually talk about mealworms with each other, and they may say things at this time that they would not during a group discussion. Be alert to their remarks, for you may hear some that you can use to stimulate class discussions.

Figure 14-1. Mealworm larvae ready for the children.



Continue the observation period as long as it seems fruitful. Have the children count their mealworms and enter that number in the frosted space on the dish top. Ask them to return the bran and mealworms to the dish and retape the covers.

Discussion. Have the children set the petri dishes aside and talk about their observations.

- What did they find out about mealworms?
- What does the mealworm look like?
- You may wish to encourage closer observation by having the children draw their mealworms.

Using student manual pages 25 and 26. The differences between growth and development are emphasized in two series of pictures. In the top rectangle on page 25, the children are to draw their smallest mealworm. As molting occurs and the worms *grow*, the pupils can draw larger mealworms in the other two spaces.

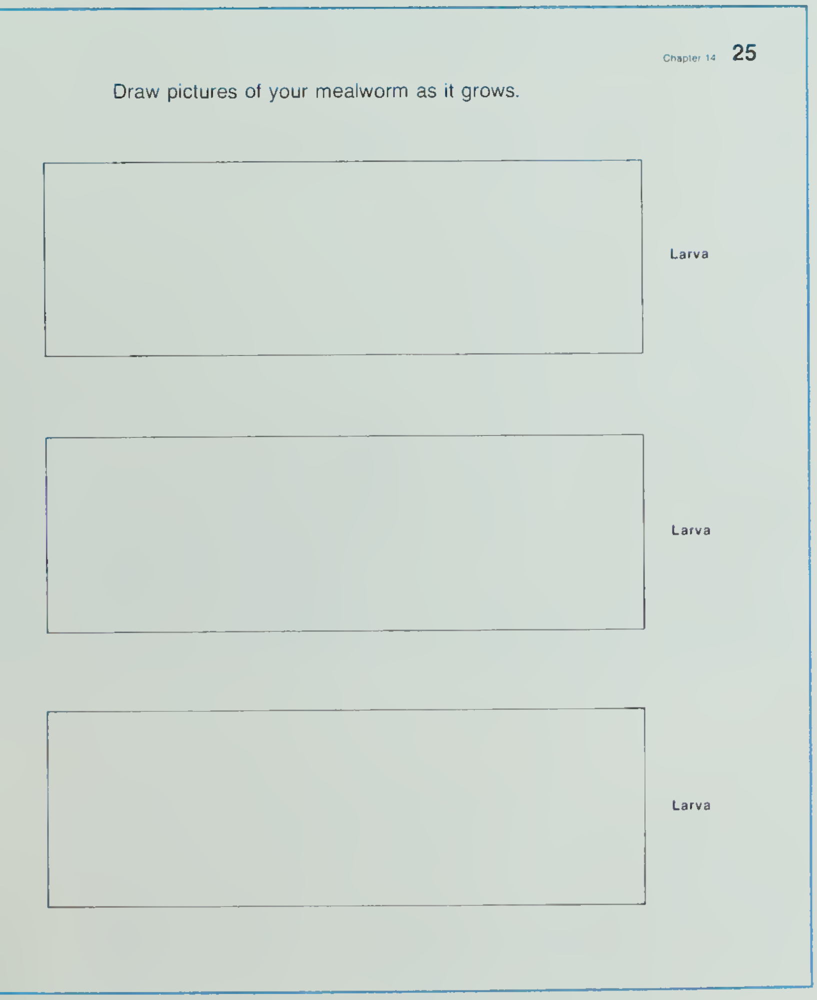
When the mealworms develop into the pupa and adult stages, they can be pictured in the proper spaces on page 26.

Informal observation. Encourage the children to observe their mealworms informally at their desks. A culture may be kept inside the desk (mealworms require little light), or the dish may be taped to the top of the desk. Every four days or so, add a small piece of potato—about the size of a gumdrop—for moisture. If the food appears wet or smells sour, encourage the students to discard the old bran and replace it with new.

Molting. Over the next week or so, the children will see shriveled skins. If they think the skins are dead mealworms, have them count their animals again and compare the numbers with their original counts. If the numbers of live mealworms are the same, ask the children what the shriveled-up objects could be.

If some children insist that the objects are dead mealworms, ask them to try an experiment to find out. They should paint a stripe on the back of each live mealworm, using red nail polish, and look at the mealworms at least every two days. When a shriveled skin is found again, the children will see that the red stripe is on the shriveled object and not on the pale mealworm (Figure 14-2). Hold a class discussion so the children can report their observations. If they cannot make the correct inference, leave the problem open.

Eventually, someone should observe a mealworm shedding its skin (molting). When this happens, write the word *molt* on the chalkboard and explain that the larva sheds its skin (molts), after which it can grow larger. Remind the class of previous discussions concerning growth.



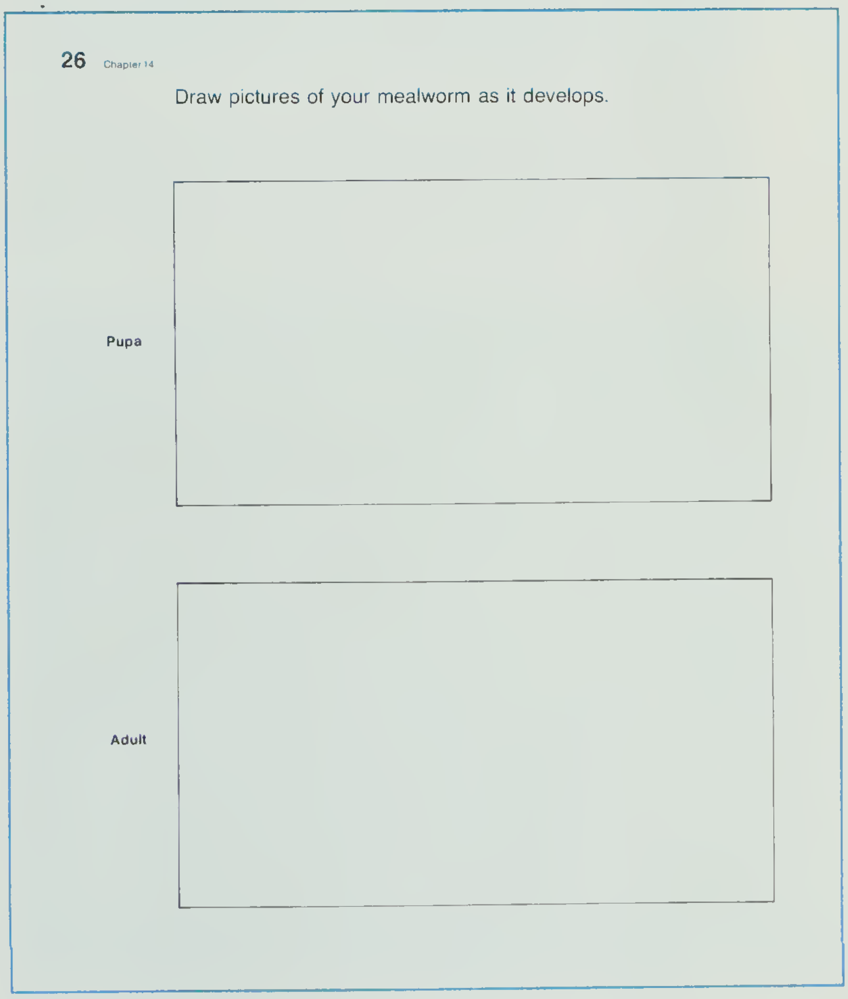
Chapter 14 25

Draw pictures of your mealworm as it grows.

Larva

Larva

Larva



26 Chapter 14

Draw pictures of your mealworm as it develops.

Pupa

Adult

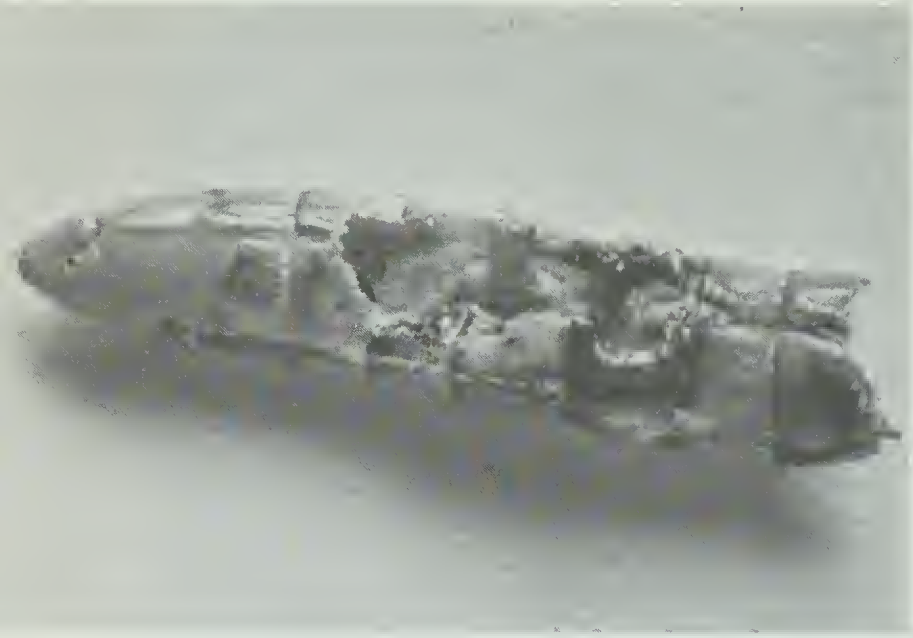


Figure 14-2. Evidence that the larval skin is shed.

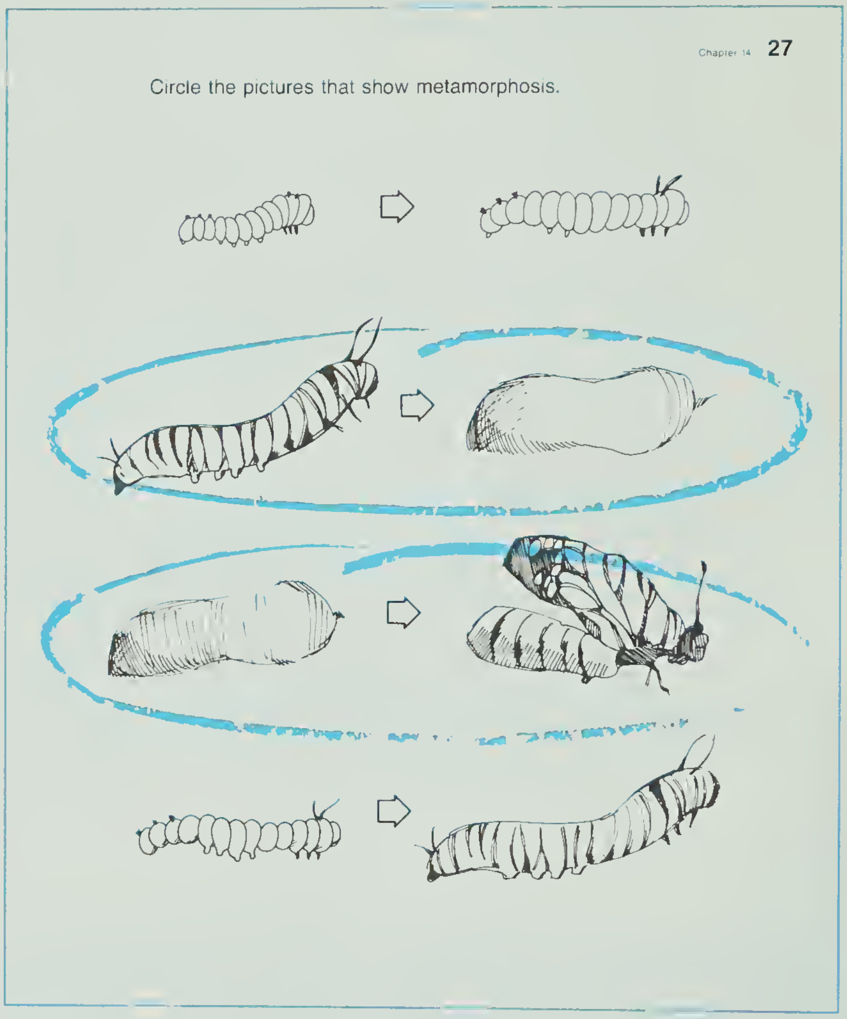
Pupae. The first pupae will appear after about two weeks. Let the children compare them with the larvae and ask where these different-looking animals might have come from. Remind the children of the fruit fly and wax moth life cycles and ask them what stage of the life cycle will come next. They may want to speculate about what animal will develop from the pupa. The students should continue their observations at least every other day.

Adults. When the adults emerge, the children should describe and compare them with the larvae and pupae. Now hold a class discussion of the mealworm life cycle. Although the children will not have seen any eggs, they may be able to infer that the adult females lay eggs, which will hatch into larvae.

Reviewing metamorphosis. Encourage the children to discuss the differences between the young and adult forms.

- In what ways are they different?
- Is the larva the same animal when it develops into a pupa? Into an adult?
- Write the word *metamorphosis* on the board and see how many remember it.
- Invite several children to give you their version of metamorphosis.
- Ask the children to name some other organisms that go through metamorphosis. (Some children may mention the wax moth, cricket, and frogs; some children may bring in their past experiences with butterflies or other animals. Even though the crickets and frogs do not undergo complete metamorphosis from larva through pupa to adult, it is all right for the children to use the term for the change from egg to tadpole or nymph.)

Using student manual page 27. Explain to the students that some of the four pairs of drawings show metamorphosis and some do not. They should circle the pairs that show metamorphosis (such as the pupa and adult pair). This task will cause them to think about metamorphosis and provide you with some indication of their ability to differentiate that from growth.



Chapter 14 27

Circle the pictures that show metamorphosis.

Cleanup. You can use mealworms as food for other classroom animals (such as lizards, frogs, and turtles), give them to other teachers for use in their classrooms, or release them in a wooded area. Wash and air dry the petri dishes and return them to the kit.

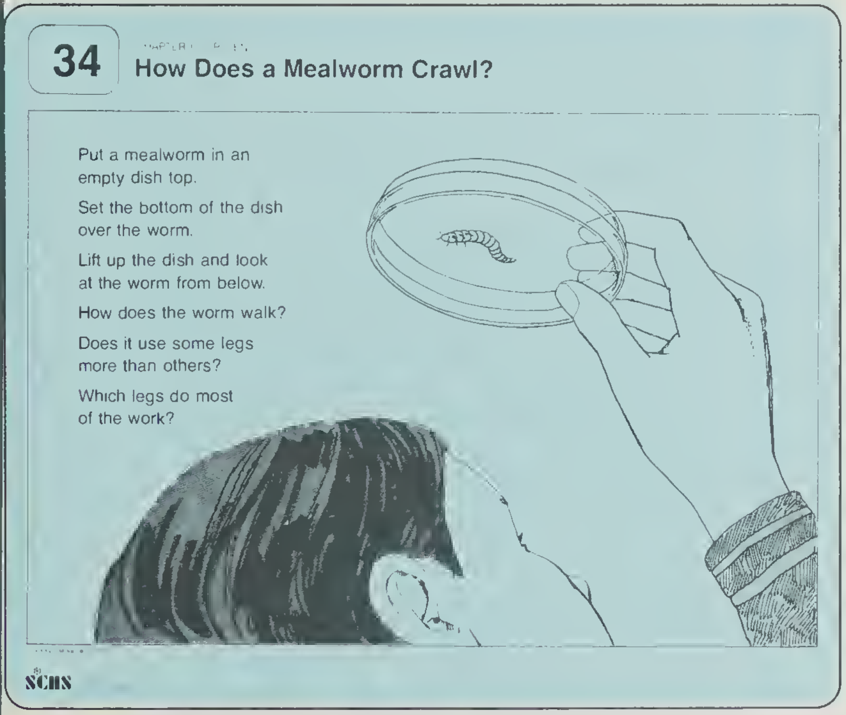
OPTIONAL ACTIVITIES

Silkworms. Silkworms can be raised successfully in the classroom if you follow the supplier's instructions for their care. Order the eggs from any of the large biological supply houses. Place the eggs in a terrarium having a few centimeters of sand on the bottom. Put a ventilated cover on the terrarium. The eggs will hatch into larvae (caterpillars) within two weeks at room temperature. The larvae prefer leaves of the white mulberry tree. If you are unable to obtain mulberry leaves, osage orange leaves (found in the eastern United States) are satisfactory. If neither of these is available, try lettuce. Wash and dry whatever kind of leaves you provide. Feed the larvae fresh food each day and change the sand once a week if possible. Silkworms get all the moisture they need from the leaves they eat, so it is not necessary to provide other water.

Prop up some small twigs or sticks in the container. The larvae will spin their cocoons on these sticks in one to two months, depending on the temperature of your room. A few weeks afterward, adult white silk moths will emerge.

EXTENDING YOUR EXPERIENCE CARDS

34. How Does a Mealworm Crawl? For children doing this activity, you will have to provide one petri dish and a mealworm. No food is necessary, although a little soil or food dust on the mealworm's walking surface often reveals the leg and foot motions better than the clear surface alone. The mealworm can easily be squashed between the dish top and bottom. Caution the children to keep the mealworms away from the dish edges and to lower the bottom carefully into the top.


34 How Does a Mealworm Crawl?

Put a mealworm in an empty dish top.

Set the bottom of the dish over the worm.

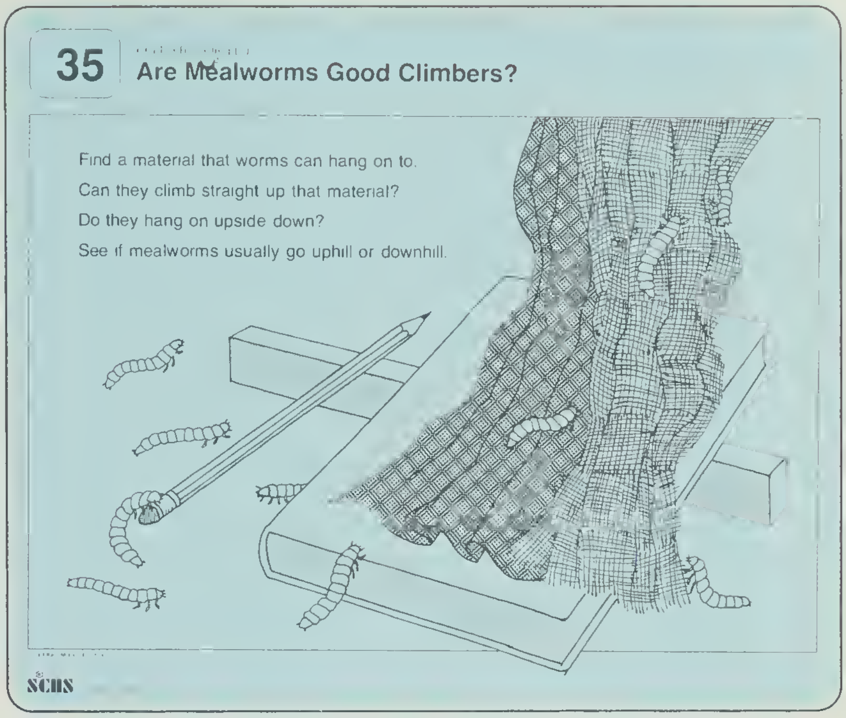
Lift up the dish and look at the worm from below.

How does the worm walk?

Does it use some legs more than others?

Which legs do most of the work?

35. Are Mealworms Good Climbers? You may have to suggest some different materials that you or other teachers may have on hand around the school. Paper towels, plastic, lunch bags, erasers (rubber and chalk), curtains, rags, wooden sticks, and various book covers make good test surfaces. Of course, a collection of various fabrics from a sewing class would be best. You will have to provide some mealworms also.


35 Are Mealworms Good Climbers?

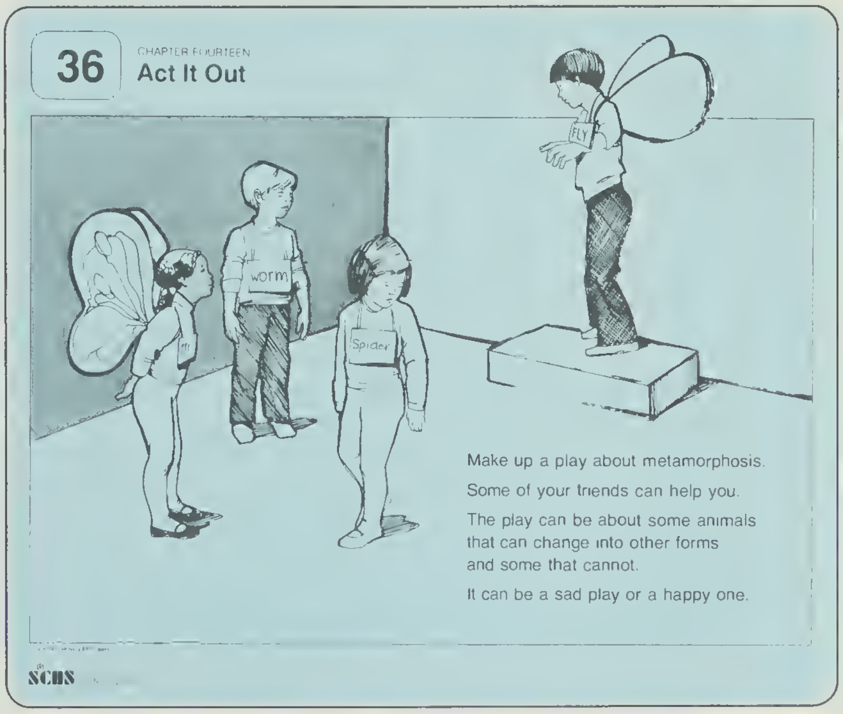
Find a material that worms can hang on to.

Can they climb straight up that material?

Do they hang on upside down?

See if mealworms usually go uphill or downhill.

36. Act It Out. Children are quite good at acting out the changes in animals as they undergo metamorphosis. Nearly every animal undergoes some kind of obvious developmental change which may be acted out by your pupils. While costumes are not necessary, a piece of colored paper worn by the actor helps the audience to guess the animals' names. Green for frogs, yellow for butterflies, and so on are some ways of designating the animals. Or, the children may prefer to tell the audience what animals are being depicted.



36 CHAPTER FOURTEEN Act It Out

Make up a play about metamorphosis.

Some of your friends can help you.

The play can be about some animals that can change into other forms and some that cannot.

It can be a sad play or a happy one.

15 Butterflies

SYNOPSIS

Children receive and observe the larvae of butterflies.

Students discover the metamorphic changes as larvae become pupae and then adults.

Suggested time: *This activity requires two class sessions with opportunities for individual observations between the two sessions.*

TEACHING MATERIALS

For each team of two children:

Drawer 2

1 magnifier

For the class:

2 butterfly cultures†
2 sticks*
1 tablespoon sugar*
twigs*

Separate package

2 butterfly houses

Drawer 3

12 small plastic zip lock bags (optional)
2 plastic vials

Drawer 4

12 tumblers

* provided by the teacher
† in Shipment LC-3

ADVANCE PREPARATION

Remove and set up the two butterfly houses according to the directions printed on the package.

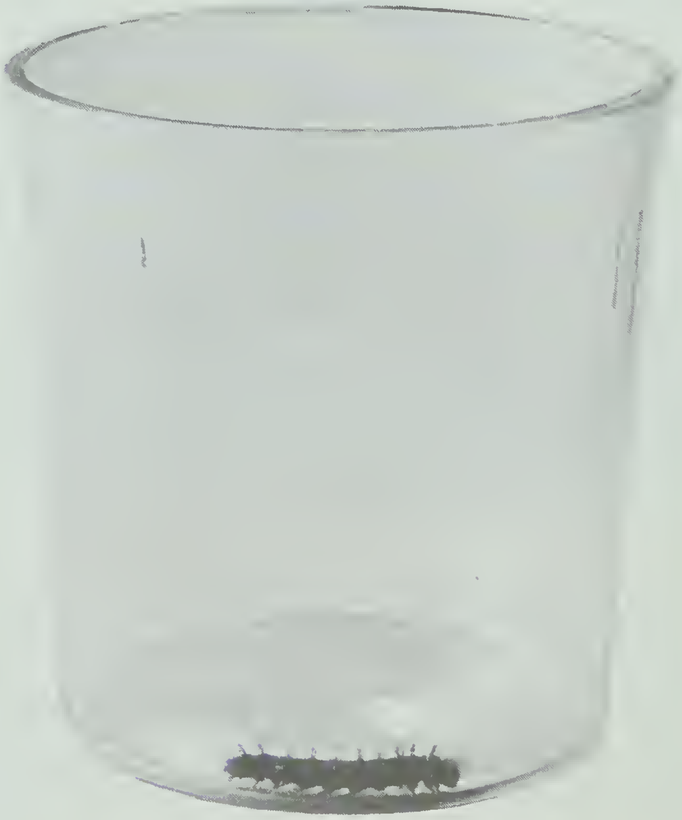
Just before class, prepare some displays by adding one caterpillar to each of twelve tumblers or planter cups for the children to see. The caterpillars may climb up to the cup rims but will usually not go farther. If you prefer, you may cover the cups with plastic bags to prevent the caterpillars' escaping.

TEACHING SUGGESTIONS

This is a discovery activity that enables students to observe development and growth in the life cycle stages of a butterfly.

Introducing the activity. Tell the students you will show them a new animal today, and distribute the display cups containing caterpillars which you prepared earlier. Exclamations and comments involving the use of the word *caterpillars* will be common. Listen for children who refer to the animals as larvae. Distribute magnifiers to the youngsters to enable them to get a closer look at the caterpillars. Have the children let the caterpillars crawl on their arms for about ten minutes; during this time they can see how the caterpillars walk and what they look like (Figure 15-1). Children who know or suspect these are butterfly or moth larvae may wonder how this thick, bristly, slow-moving animal is ever going to fly.

Figure 15-1. A display tumbler containing a larva.



Identifying the larvae. After everyone has had an opportunity to interact with the new animals, ask the entire class if it knows what these animals are called. Most students will respond with the correct term "caterpillars." Then see if they know which life cycle stage the caterpillar is going through. At this time in the unit, the children should have little difficulty identifying caterpillars as larvae. Those children who suggest caterpillars are pupae, eggs, or adults need extra experience with the life cycle cards and perhaps with live animals as well.

After you have determined that the children understand this animal is a larva, tell them it will become a butterfly.

Some of the children will probably be very pleased to tell the others about their experiences and familiarity with butterflies. You may want to encourage all the children to draw color pictures showing what they think the butterflies will look like. When this is completed, you can see if the children think the larva's coloring is related to the coloring of the butterfly that it will become.

Discussing development and growth. Growth will occur in the larva before it becomes a pupa. As it pupates, metamorphosis is occurring. During the pupal stage, the larva is changing into a new form—the adult—which will have wings. So, there are many opportunities for the children and you to use the terms *development, growth, metamorphosis, larva, pupa,* and *adult* during this activity. By using all of your opportunities with this new organism, you are helping the children to understand how all the new terms they have learned over a longer period of time fit together.

Ask some questions to stimulate thinking about the future growth of the larva and its development into a pupa and an adult butterfly:

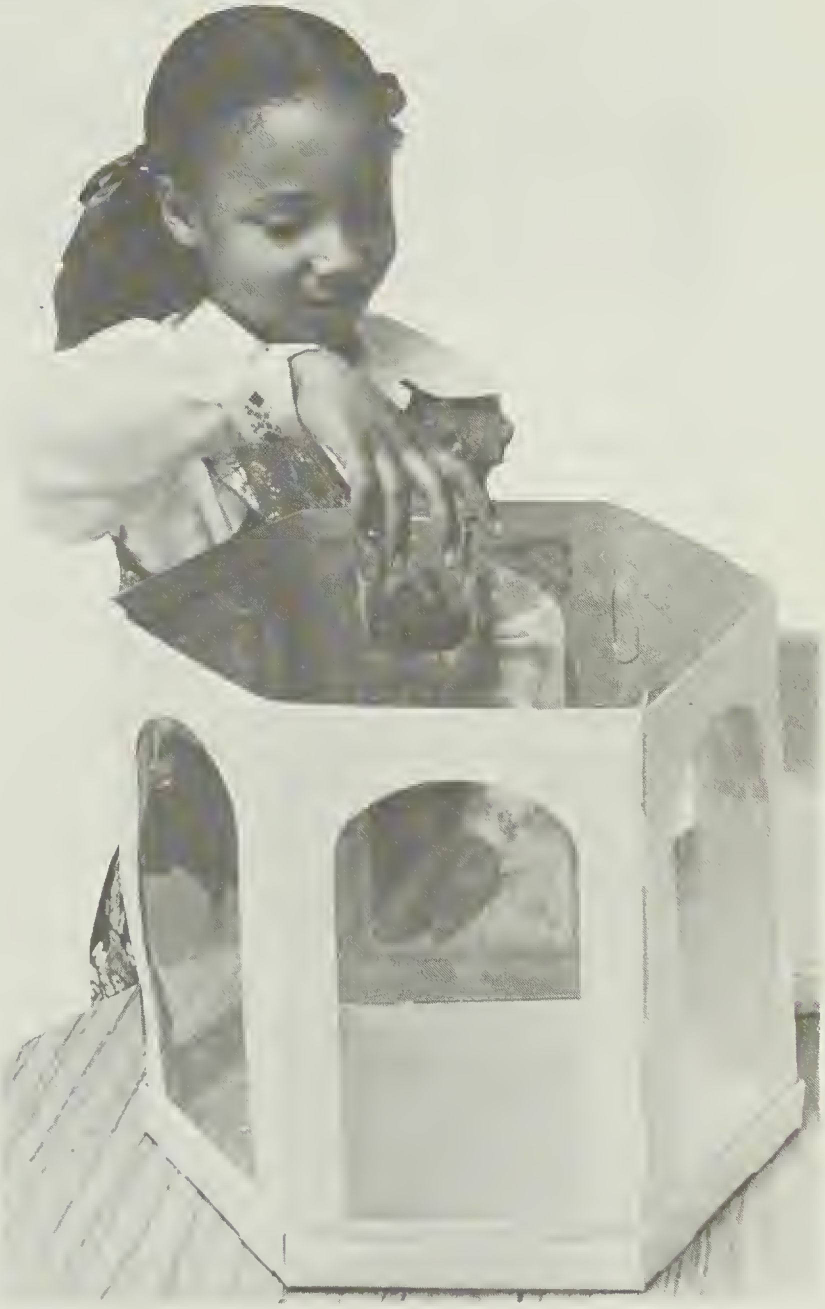
- What do you think this larva will look like tomorrow? Next week? Next month?
- If you wanted to carry a butterfly in your pocket without hurting it, what stage of its life cycle would be best?
- Do you think that the larger larvae will turn into larger butterflies than the smaller larvae will?

Maintaining the butterfly larva. Show the children the butterfly houses and let them put half the larvae in each house. After this is done and the children have returned to their seats, show them the larva food so they will know the larvae have food to eat. No further care will be necessary until the adults emerge from the pupa stage.

Casual observations. About every three days, encourage a few children at a time to examine the houses to see what is happening to the larvae. As long as the children handle the larvae carefully, they may remove and observe them. It is better to have them do this at the houses than to carry the larvae all around the room. In classroom trials, we have noticed many second graders are so worried about squashing the animals that they drop them.

The pupa stage. Ten to twelve days after you receive the butterfly larvae, some will pupate. The larva climbs onto a stick and secures itself by one end. Its body undergoes a noticeable change caused by the formation of a tight skin around the animal. The children will be able to see what looks like a caterpillar head on the floor of the house under each larva. This is skin that has been molted. The metamorphosis of the larva into an adult will occur during the pupa stage which will last about twelve days, depending on the temperature.

Figure 15-2. Adding larvae to the butterfly house.



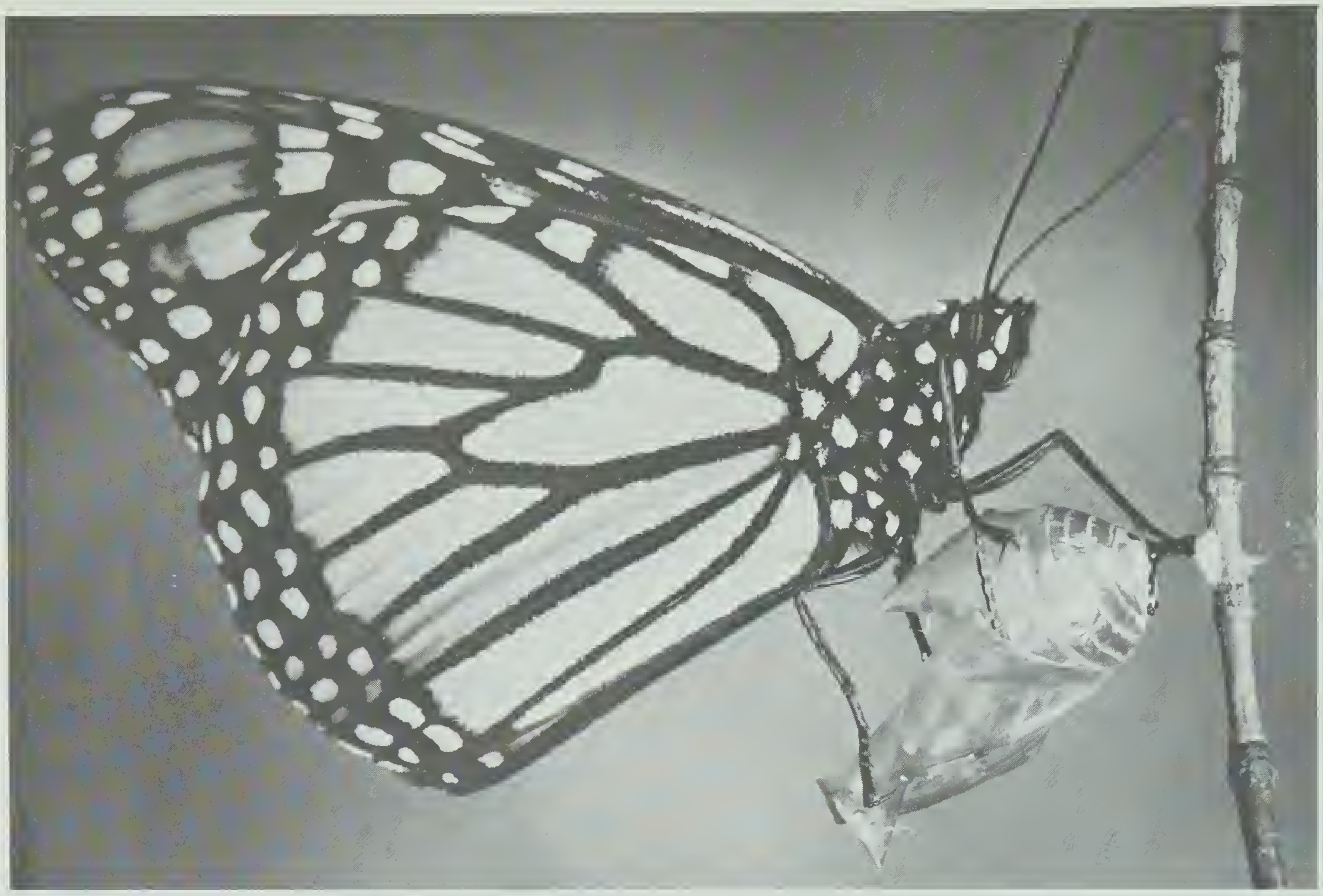


Figure 15-3. Emergence of a monarch butterfly.

Observing the pupa. There is usually little interest in observing the pupa stage, because it appears to be inactive. Many changes are taking place, but most of the activity is internal. Removing the stick (if the larva chooses a stick from which to suspend itself) from the house to better observe the pupa is permissible, as long as the pupa case is not broken off the stick.

Emergence. About twelve days after the pupa stage began, you can expect to see a butterfly somewhere inside the house. Prepare the sugar solution prior to this expected event so that it is immediately available to the adult—especially if the twelfth day might fall on a weekend. Follow the directions which come with shipment LC-3. (Different butterflies may be supplied at different times of the year. Their diets differ, so the diet is not prescribed in this guide.)

There will be considerable excitement when the first butterfly is discovered. First let everyone see it (keep it inside the house for now), then have one or two children find the pupa case from which the adult emerged. It is noticeable, because it will be split from end to end. When this empty case is found, break it off and remove it from the house for the children to see.

Review of *life cycle*. Through short plays, stories, some chalkboard drawings, or descriptions, let some of the children review the life cycle concept for you and the class. See how many of the terms are used, whether the sequence of the cycle is correct, and whether the children give evidence of understanding that individual organisms may die but new ones just like the originals are being born or hatched to replace them. Some children may use the butterfly, others may use any of the plants studied in the unit, and still others may describe the life cycles of organisms not seen in this unit.

What to do with the butterflies? After all or most of the butterflies have emerged, you can keep them in the classroom until they die. If you wish to dispose of them earlier, place them in a bag, seal it, and place the bag in a freezing compartment of a refrigerator for a day. Discard the bag in the trash.

Cleanup. Unfold the houses and wash off the bottom flap and any other part that has been directly dirtied by the animals. Pat dry with a towel, refold the house, and store it in the kit for future use. Discard any extra food—it will not keep.

16

Caterpillars

SYNOPSIS

Children discover the transformation from larva to adult in caterpillars or other local animals that they collect and identify on a field trip.

Suggested time: ***one class session, plus later observations***

TEACHING MATERIALS

For each child:

student manual pages 28–30

For each team of two children:

transparent tape or glue*
masking tape*
construction paper*
small paper bags*

Drawer 2

1 magnifier

Drawer 3

large plastic zip lock bag

* provided by the teacher

ADVANCE PREPARATION

This activity can be done only when caterpillars (or some other larval form of a local animal) are available in your area of the country. If that happens before it is time to do this chapter, take advantage of the opportunity and conduct this activity out of sequence. Select an area that is convenient and that has many caterpillars.

TEACHING SUGGESTIONS

Collecting and studying organisms in various stages of development contributes the final discovery phase for this unit.

Collecting organisms. Tell the children they will be going on another field trip, this time to look for caterpillars. Many of the children will have seen them and may know their habitat—where they can be found. Set up these ground rules:

- Each team is to bring back only one caterpillar.
- Children should also bring some of whatever food the caterpillar is eating. Arrange for each team to get one plastic bag and take it with them.

While on the field trip, remind the children to see what the caterpillars are eating and to bring in a handful of that material. Each team should also pick up a stick about 15 cm long. This will be put into the caterpillar house for the animal to climb on.

Once back in the classroom, have the children compare their caterpillars and the foods they were eating. Then ask:

- What part of its life cycle is the caterpillar in now? The egg, larva, pupa, or adult?

The caterpillar is the larval stage of a moth or a butterfly, but the children cannot be expected to know that for certain. However, they may correctly identify it from their previous experiences with the wax moth and mealworm larvae.

If the children do not recognize caterpillars as a larval stage, they can experiment by keeping the caterpillar for a couple of weeks to see if it changes into any other stage. Even if they are satisfied that caterpillars are the larval form of some animal, they may want to see what kind of animal it becomes.

Constructing caterpillar homes. Set up a caterpillar home as a demonstration for the children:

- Insert a twig or stick into a large zip lock bag and turn the stick sideways to push the sides of the bag apart. If the collected sticks are unsuitable for this, you can substitute one of the wooden sticks from the kit.
- Put a few of the leaves or other food material into the bag, add a caterpillar, and zip the bag together.

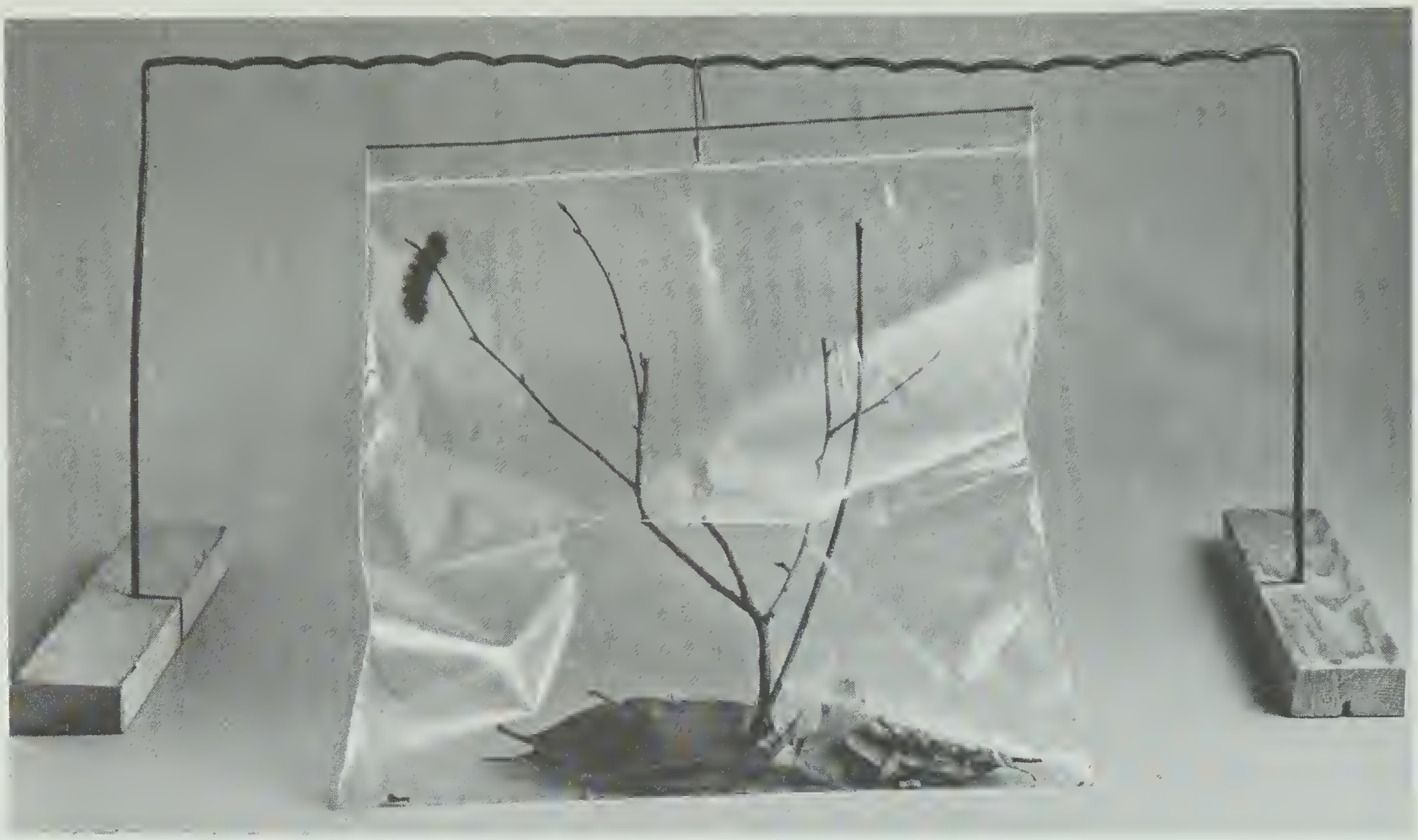


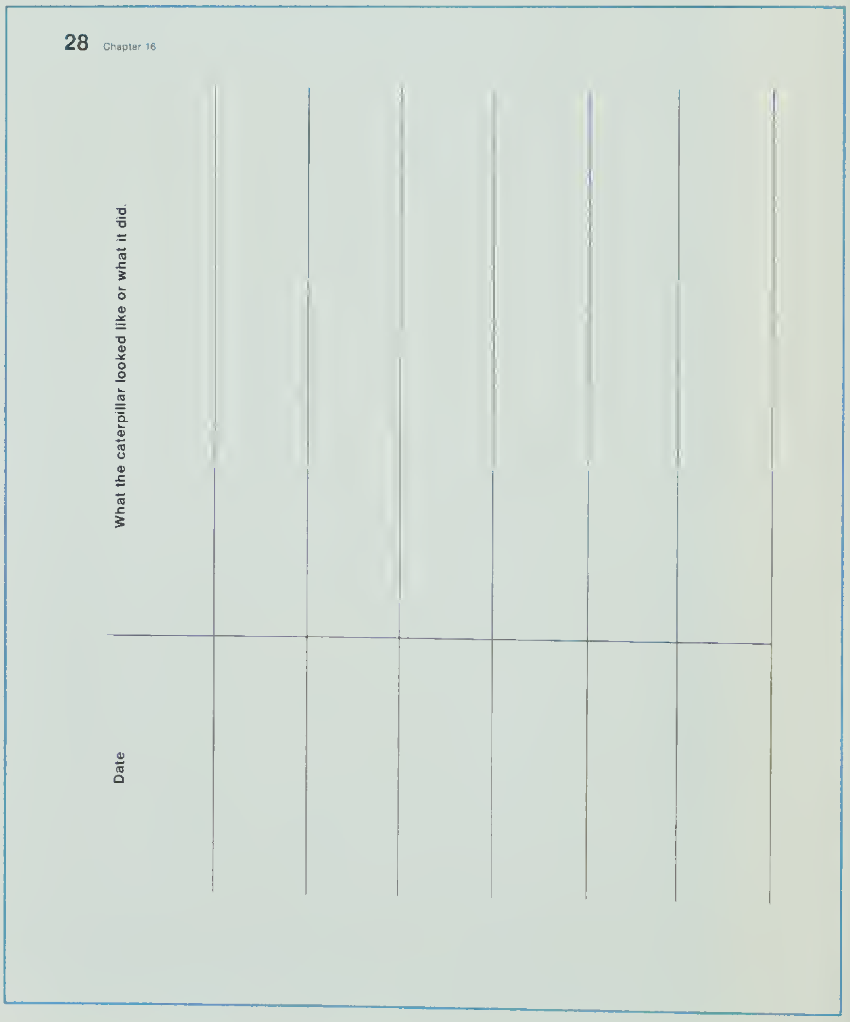
Figure 16-1. A set up caterpillar home.

- Label the bag with a piece of masking tape having your name on it. Using tape, hang the bag from a wall shelf, chalk tray, or other convenient spot. After your demonstration, encourage the children to construct their own caterpillar homes.

Observing caterpillars. Using magnifiers, the children can watch the caterpillars eat. They should air out the bags every other day by opening the zip locks and adding new food if needed. If the bags stay open for about a minute, enough air will exchange to keep the caterpillars healthy.

The caterpillar will probably eat continuously, night and day. If you will permit the children to take their caterpillars home one night, they will have the opportunity to see that for themselves. (Lunch bags are good, unobtrusive containers in which to carry them home, especially important if your students ride buses with older youngsters, who might disturb the caterpillars.)

Using student manual pages 28 and 29. If the caterpillar is not already fully grown, it will become noticeably larger as it continues to eat. On pages 28 and 29 is a chart where the children can record the animal's size, shape, or other characteristics. Students may either trace the animal on successive days in order to record its growth, or paste a paper silhouette of the animal onto the appropriate space. If



28 Chapter 16

What the caterpillar looked like or what it did.

Date

the children write the date in each outline, they will have a record of the growth and development of their animal.

At the points when the animal undergoes metamorphosis, the children can print *M*'s. The adult stage will be drawn on page 30.

Pupae. The larva will construct a cocoon one day and will then disappear for five to fifteen days. When this happens, ask the children what stage of the life cycle they think the cocoon indicates. They should remember the time you exposed a wax moth pupa when you opened a cocoon.

No further feeding is required now, and all food material should be removed from the bag. Be sure that the children continue to air the bags every other day. The pupa, although not visible or moving, is undergoing active developmental changes that require oxygen. Keep the animals at room temperature during this stage of the cycle.

Adults. The time the animals remain in the pupal stage depends on the kind of insect the children have found and on the temperature. You can use this time to review the concept of metamorphosis.

When a moth or butterfly emerges from a cocoon, take advantage immediately of the opportunity for the children to see this example of the adult stage following a pupal stage. Have the children observe the animal's new shape and its behavior as compared with the caterpillar.

Using student manual page 30. Observations of the adult animals can be recorded here. Not all the adults will emerge at the same time, and so other opportunities to see this event will occur. The children can add to their observations later. Each individual should record the date his or her adult animal appeared.

Discussion. The emergence of adults from pupae in the cocoons will cause excitement and some concern over what to do with the moths or butterflies. Tell the children they can keep the adults for one day; then they will free the animals to find food, mate, and lay eggs. It is not necessary to kill these animals, as they were collected locally. Many kinds of adult moths and butterflies do not eat at all, and other kinds may have unknown food preferences or be very inconvenient to feed.

Prior to letting the adults fly away, hold a discussion of the life cycle of this animal. Such topics as how much food the larva ate, when it stopped eating, how it grew, how it made the cocoon, and its metamorphosis from a larva to a pupa will encourage the

Chapter 16 29

30 Chapter 16

What the caterpillar finally became

Date

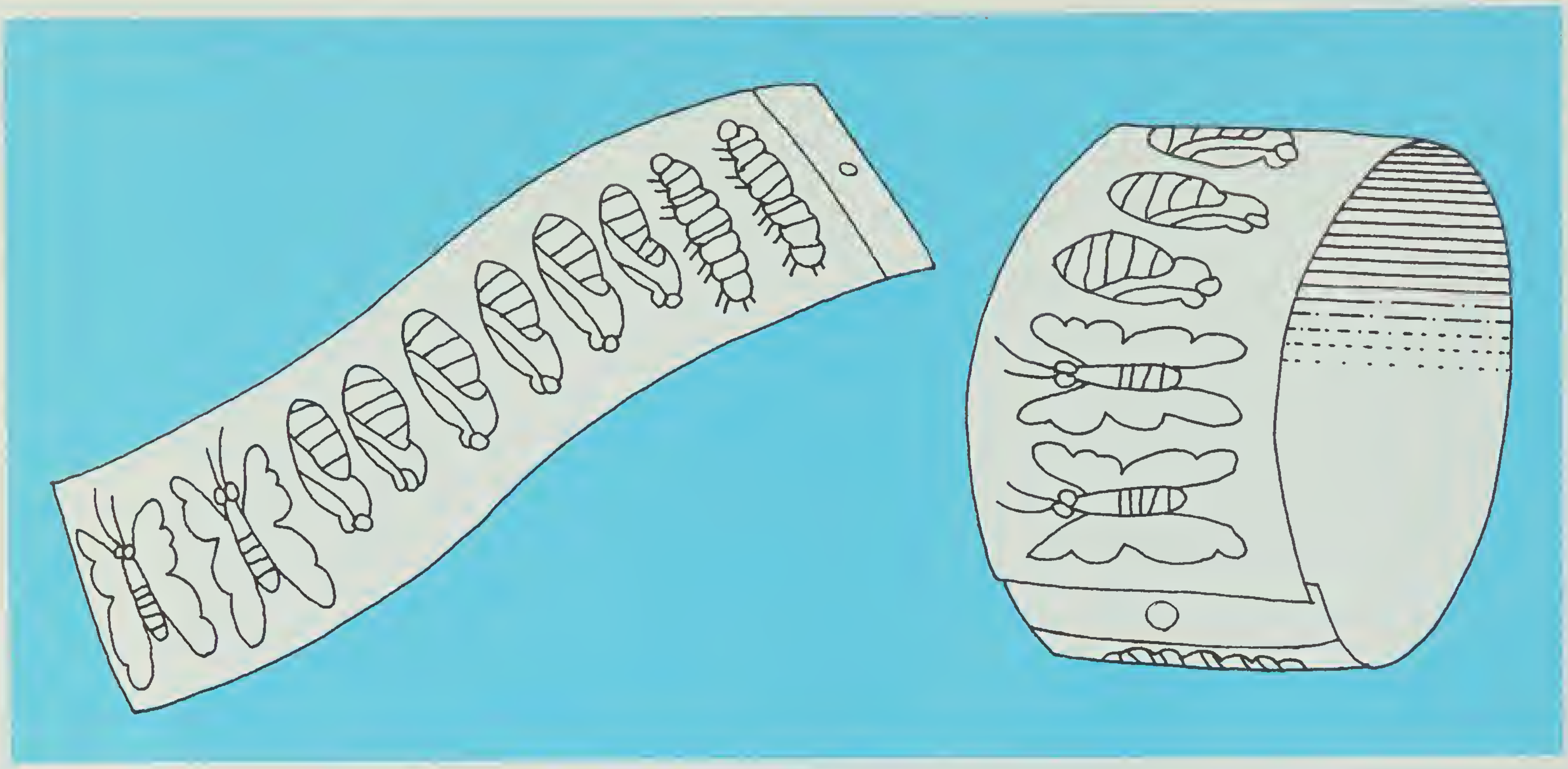


Figure 16-2. *(Left)* A life cycle time strip, with the egg stage added. *(Right)* A life cycle wheel.

children to describe events related to the life cycle of this animal. As the children talk, draw the stages or write the names on the chalkboard. The children should notice that the egg is not represented but should know where to insert that stage in the cycle.

Making a life cycle wheel. Using the record of dates, growth, and development from student manual pages 28–30, invite the children to make a life cycle wheel. It is nothing more than a piece of light-colored construction paper, 4 cm wide and 20 cm long, with the events of a life cycle recorded on it.

After adding all the details to the strip of paper, show the children how to connect the two ends to form a circle. This model of a life cycle can be rolled along like a hoop. As this is done, the stages will appear to a viewer's eyes.

Freeing the adults. Take the children back to the caterpillars' habitat to release the adults. They can open the bags, lift out the twig with the adults on it, and set the stick on a bush or on the ground. Many moths or butterflies will fly away within a few minutes. After returning to the classroom, rinse out the zip lock bags and hang them up to dry.

The children may want to know what you think will happen to the adults they just released. You can fill in the part of the life cycle they could not see—the mating and resultant egg laying that starts the life cycle over again.

If the weather is cold, the children may be concerned about the adults' ability to live. Most insect adults do die when the temperature is very low, even if they emerged outdoors. However, unless it is very cold, some of the released adults will mate and lay eggs. In general, the adults and larvae are more sensitive to cold, and the egg or pupa is the stage that remains alive over winter. Then, when the warm weather comes, these stages begin developing again, continuing the life cycle.

OPTIONAL ACTIVITY

Other life cycles. Conduct the same kind of investigation with worm or snail eggs found in the soil or with eggs found in ponds or slow-moving streams.

In digging around flower beds or under logs and limbs, you may find the pupae of various animals. Bring them into the classroom along with some of the soil or water in which you discovered them. Set up an appropriate viewing chamber, such as a clear plastic shoebox, which will allow the animal to continue through its life cycle.

You will need to provide appropriate food for any larval stages. Try a variety of leaves from the animal's habitat.

Have the children release all adults, so that classroom activities will not affect the population sizes of your local organisms.

EXTENDING YOUR EXPERIENCE CARDS

37. Racing Larvae. The child will need containers such as planters, tumblers, zip lock bags, bottles, or cans which can be covered. Use some porous material, such as cheesecloth or fabric, as covers. Twigs and whatever the larvae are eating should be added.

38. Differences in Caterpillars. No preparation for this activity is necessary unless you would like the children to see a variety of caterpillars. In that case, you may want to prepare a ditto for all the children to use as a record sheet. All the caterpillars will have six legs, most are colored, and because they move slowly they appear tame.

37 CHAPTER SIXTEEN
Racing Larvae

Find several larvae of the same kind.

Put each larva in a cup with some soil.

Add the same amount of food
to each cup.

Cover the cup.

Guess which larva will develop
into a pupa first.

See if you are right by checking
each day.

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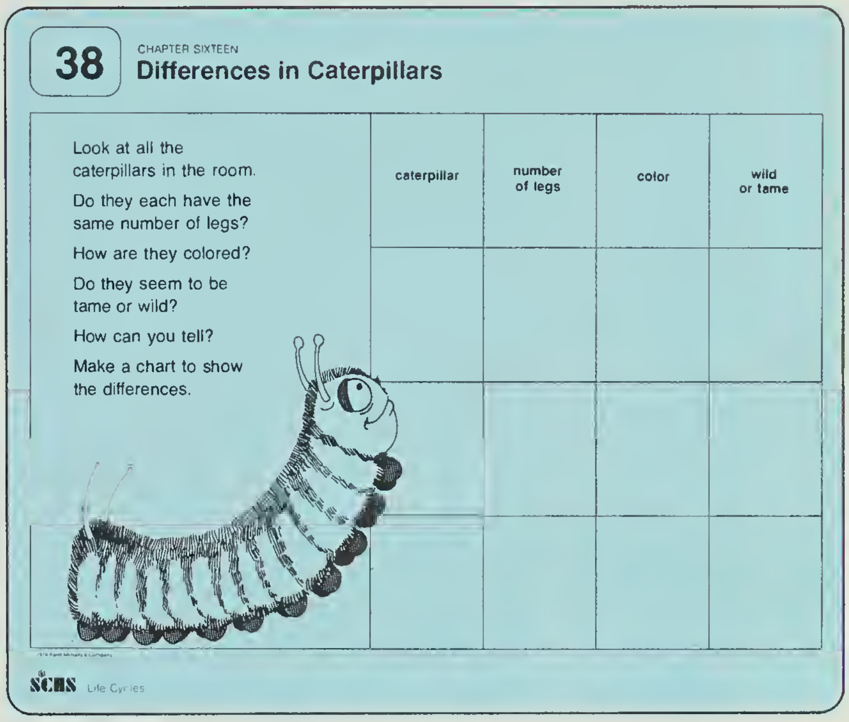
SCIIS Life Cycles



38 CHAPTER SIXTEEN
Differences in Caterpillars

Look at all the
caterpillars in the room.

Do they each have the
same number of legs?

How are they colored?

Do they seem to be
tame or wild?

How can you tell?

Make a chart to show
the differences.

caterpillar	number of legs	color	wild or tame

SCIIS Life Cycles

17

Hunting for Life Cycle Stages

SYNOPSIS

Children search for animals in various stages of development to discover how animals differ from each other and from other stages.

Suggested time: ***one session***

TEACHING MATERIALS

For each child:

student manual pages 31 and 32
wooden stick (or spoon*)
plastic bag (optional)
pencil*
2 index cards*

For the class:

scissors*
paste or glue*
incubator (optional)

* provided by the teacher

ADVANCE PREPARATION

Select a site near the school where there is as much vegetation as possible.

TEACHING SUGGESTIONS

This is a discovery activity.

Finding life cycle stages. Announce to the children they will be going on another field trip, this time to look for different life cycle stages of all kinds of animals. Ask them what the four life cycle stages are; for each stage have one child describe its general appearance.

Tell the children they may not find all the life cycle stages on top of the ground. Some may be in the soil. Show them the wooden sticks (metal spoons from the cafeteria are better if you can borrow some) with which they can dig under bushes, next to concrete or brick, or under rocks and old rubbish. Other good places to look are on the branches of bushes and trees and under leaves that have fallen to the ground. The adult and larva life cycle stages are often above the soil, near food. The egg and pupa stages, which may have to survive cold or dry periods, are often found in the soil or under objects which have been lying on the ground for some time.

Ask the students to tell others whenever they find an animal, so that everyone will be able to help guess its life cycle stage. If the weather is cold, give the children some plastic collection bags. They can then bring the animals indoors and discuss them in the warm classroom. Give every child a stick, two or three index cards, and a pencil before taking the group outdoors.

Deciding on life cycle stages. When an animal is discovered, encourage the children to sketch it on one of their index cards and to decide if it is an egg, larva, pupa, or adult.

In cases difficult to decide, suggest they take one example back to the classroom to let it develop into the next stage.

Using student manual page 31. Upon returning to the classroom, ask the students to examine either the illustrations they drew or the actual animals, and to decide what life cycle stage is represented. They can then cut out and glue their drawings in the correct spaces in the manual.

Using student manual page 32. This page contains six rows of different animals. Each row contains the four stages of that animal's life cycle but in a random order. The children should place a 1 on the egg, a 2 on the larva, etc., to indicate the proper sequence of metamorphosis in the animal's life cycle. In the life

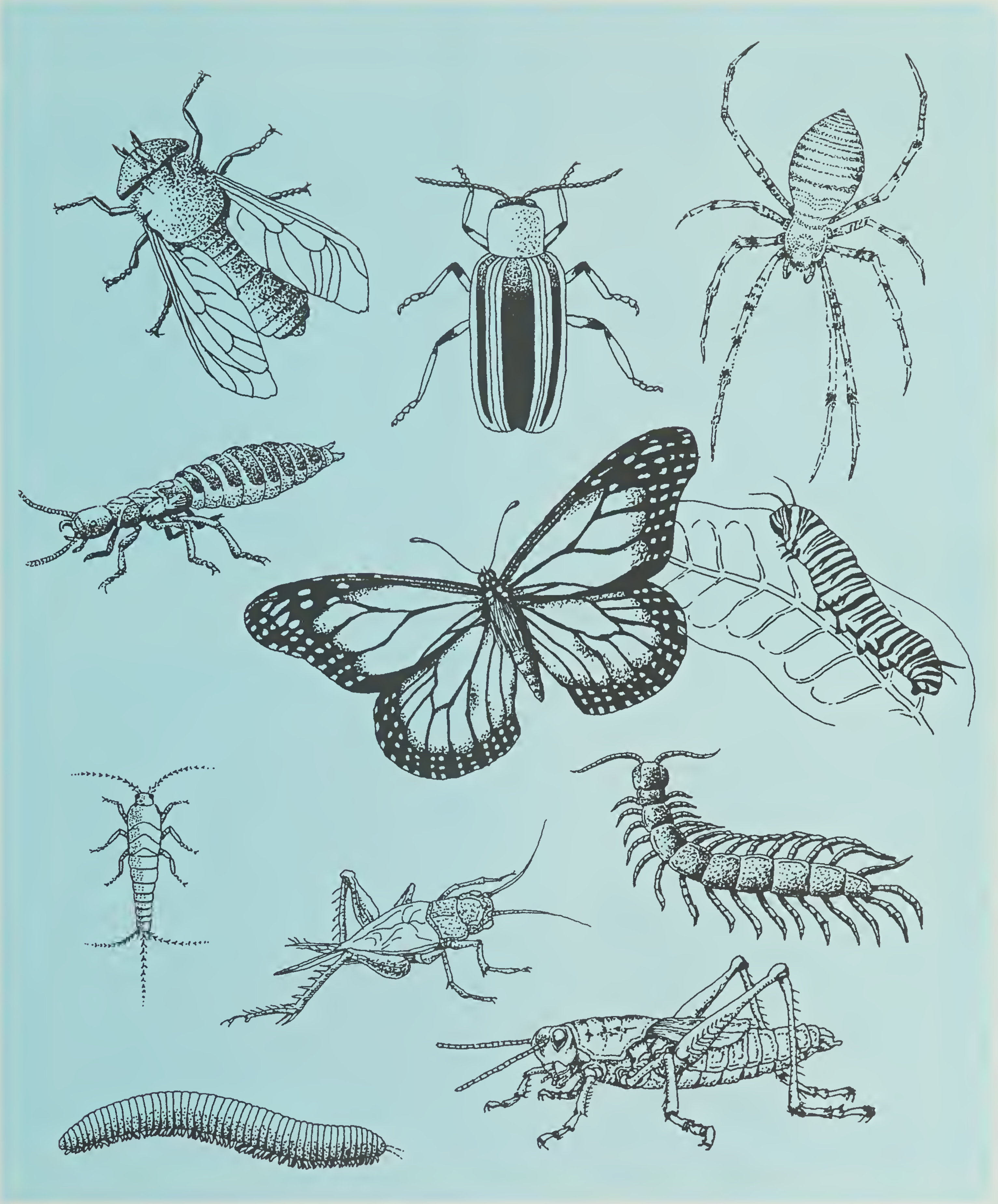
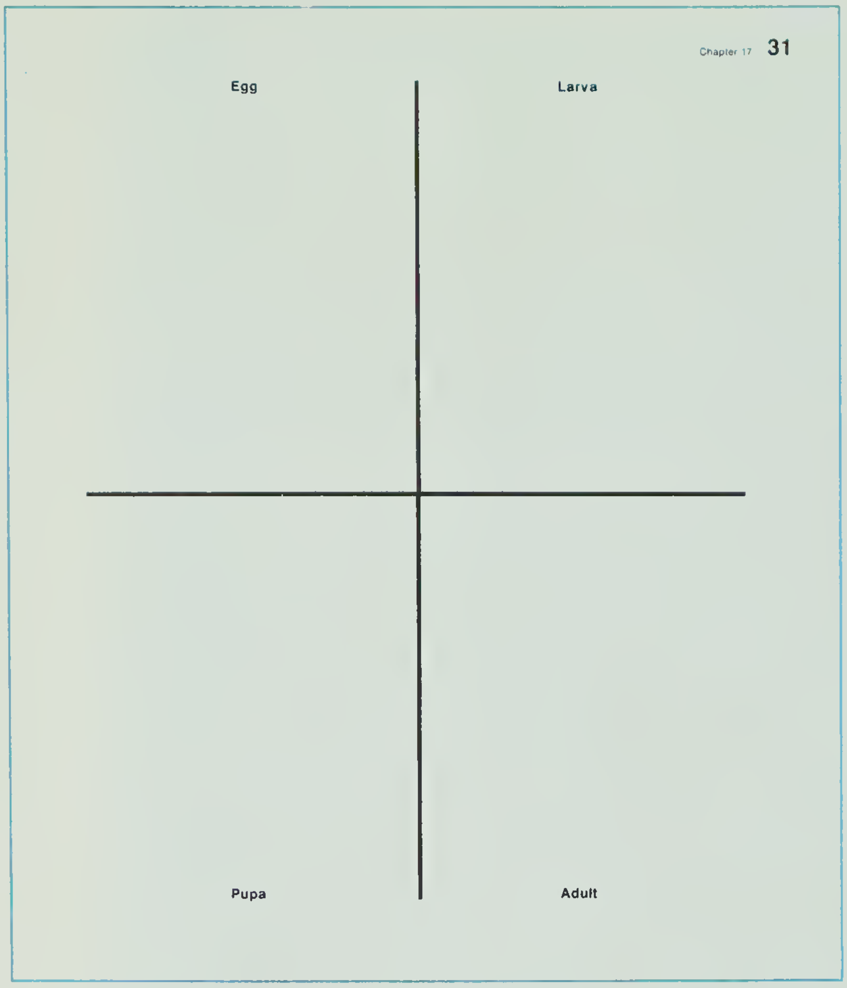


Figure 17–1. Some animals that might be found during the field trip *(clockwise from top left)*: house fly, cucumber beetle, orb-weaver spider, monarch butterfly and larva, centipede, grasshopper, cricket, millipede, silverfish, and termite. Children may mistakenly identify a spider as an insect, or a millipede as a larval stage. Encourage them to correct their mistakes by counting legs, letting "larvae" develop, and so on.



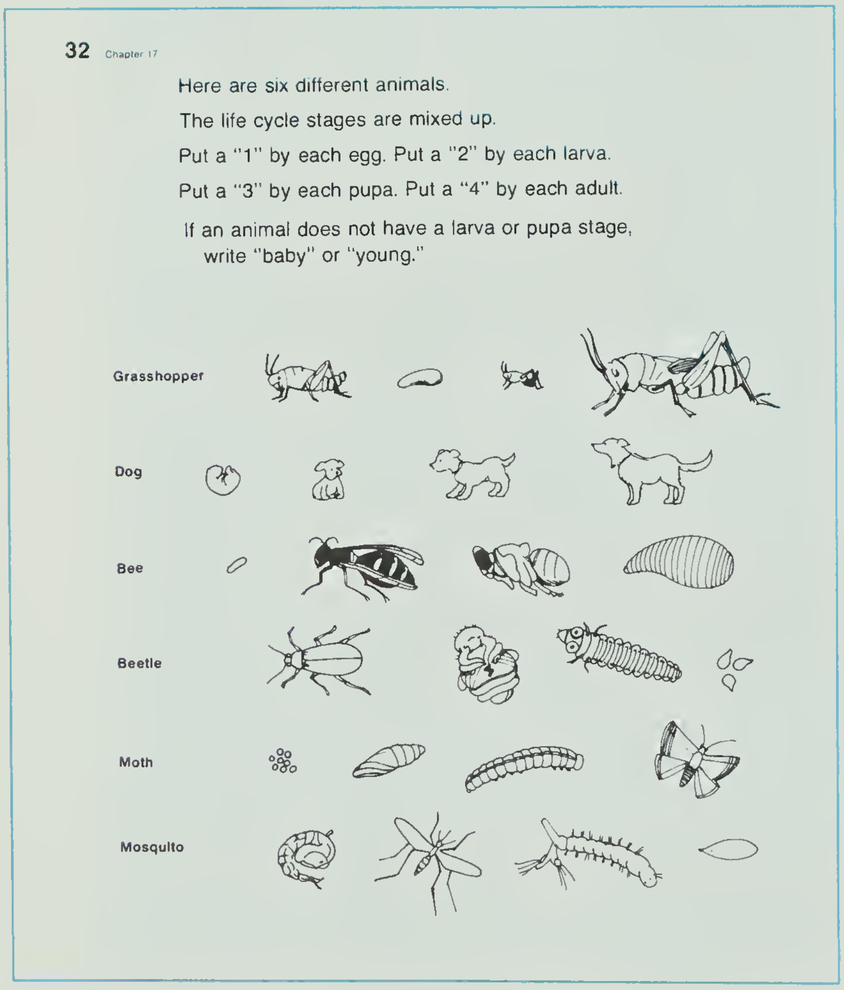
Chapter 17 31

Egg

Larva

Pupa

Adult



32 Chapter 17

Here are six different animals.

The life cycle stages are mixed up.

Put a "1" by each egg. Put a "2" by each larva.

Put a "3" by each pupa. Put a "4" by each adult.

If an animal does not have a larva or pupa stage, write "baby" or "young."

cycles of both grasshoppers and dogs, there are no larval or pupal stages. Children who realize this are thinking. Instead of numbering these illustrations, they should write *young* or *baby* next to those stages.

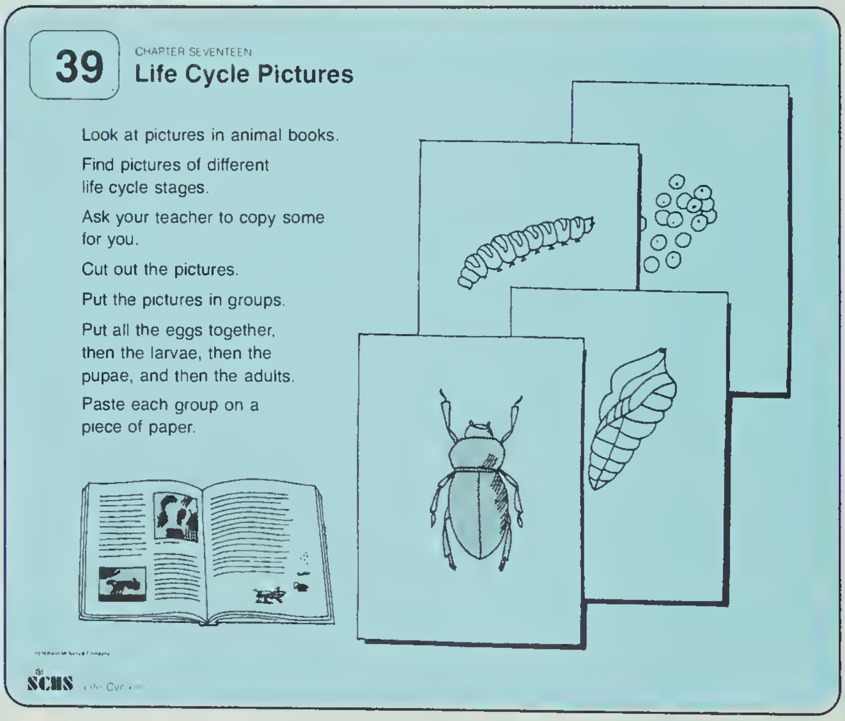
This activity will not be very difficult for the children and will probably give them some confidence that they can now recognize the life cycle sequence of animals they haven't even seen.

OPTIONAL ACTIVITY

Guess My Stage. Organize an identification game in which one child acts the part of any one life cycle stage of any familiar organism. The class then identifies the stage depicted. This game can be made more complex by asking the children to name not only the stage but also the animal.

EXTENDING YOUR EXPERIENCE CARDS

39. Life Cycle Pictures. Encourage the children to find pictures in whatever life science books you have available but be sure they understand that no pictures should be cut out of the books. Your copies will be black and white, and so the children can color the pictures to match the original illustrations.



39 CHAPTER SEVENTEEN

Life Cycle Pictures

Look at pictures in animal books.

Find pictures of different life cycle stages.

Ask your teacher to copy some for you.

Cut out the pictures.

Put the pictures in groups.

Put all the eggs together, then the larvae, then the pupae, and then the adults.

Paste each group on a piece of paper.

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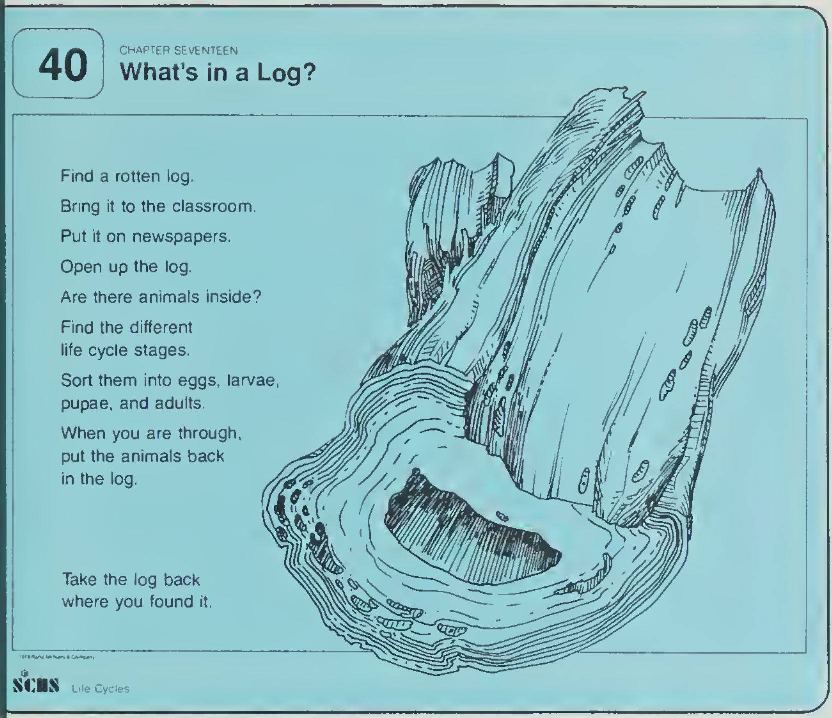
40. What's in a Log? Several children might cooperate in using this card and in finding as large a rotten log as they can carry back to the classroom.



40

CHAPTER SEVENTEEN

What's in a Log?

Find a rotten log.

Bring it to the classroom.

Put it on newspapers.

Open up the log.

Are there animals inside?

Find the different life cycle stages.

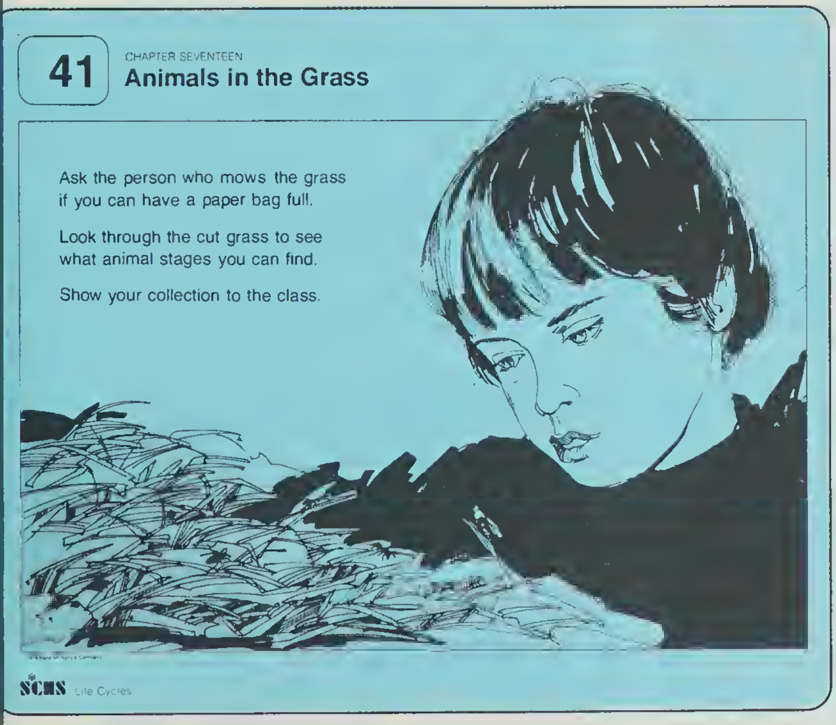
Sort them into eggs, larvae, pupae, and adults.

When you are through, put the animals back in the log.

Take the log back where you found it.

SCIS Life Cycles

41. Animals in the Grass. Animals in grass are likely to be in the larval or adult stages of their life cycles.



41

CHAPTER SEVENTEEN

Animals in the Grass

Ask the person who mows the grass if you can have a paper bag full.

Look through the cut grass to see what animal stages you can find.

Show your collection to the class.

SCIS Life Cycles

Extending Your Experience cards 1–41 are now available for the children's use. For materials needed, refer to the equipment list accompanying the set of cards.

CONCEPT / PROCESS EVALUATION

If you choose to evaluate the children's understanding of the concepts of (1) animal growth and development and (2) life cycle stages, turn to pages 97 and 100 of the evaluation section at the back of the guide.

Appendices

RAND McNALLY

SCIIS

Evaluating Your Students

SCIIS bears upon many aspects of each child's growth and learning, and evaluation may therefore take a variety of forms. We believe the most significant evaluation should occur informally, while the regular classroom activities are going on and you can observe each child's attitudes, skills, and performance, rather than in formal "test" situations. Test scores alone are not appropriate to describe attitudes, and they often are inadequate measures of children's skills or understanding of science concepts. For these reasons we have provided three kinds of evaluation activities:

A. CONCEPT/PROCESS EVALUATION
- **Activity 1. Classifying Organisms**
- **Activity 2. Describing Plant Growth and Development**
- **Activity 3. Describing Animal Growth and Development**
- **Activity 4. Recognizing Stages in Life Cycles**

B. ATTITUDES IN SCIENCE

Curiosity	**Critical Thinking**
Inventiveness	**Persistence**

C. PERCEPTION OF THE CLASSROOM ENVIRONMENT
- **Our Science Class**

An important feature of the evaluation materials is that they can help you identify problem areas and plan more effective teaching of subsequent parts of the unit. In concept/process evaluation, the "Follow-up" section at the end of each activity provides specific suggestions for remedying weaknesses in student understanding. The materials for assessing children's attitudes and their perception of the classroom environment contain suggestions that can help you improve your teaching effectiveness as well as the attitudes and performance of students. We hope you and your students find these activities both enjoyable and beneficial.

Concept / Process Evaluation

The activities in this section are designed to help you evaluate children's ability to identify and describe the major science concepts and processes of the unit. As explained in the unit "Overview" on page 1, these major concepts and processes are:

growth	**life cycle**	**plant and animal**
development	**genetic identity**	**metamorphosis**

In addition, certain secondary concepts and processes are introduced to help the children deal with their observations. These are: living, dead, nonliving, egg, larva, pupa, adult, experiment, fruit, molting, seed.

Objectives indicating the concepts and processes emphasized are listed at the beginning of each Part in the Teacher's Guide. Children's understanding and mastery of most concepts and processes can be evaluated informally as the class works through regular activities. It is worthwhile to evaluate children more than once during the unit, because individuals will achieve desired levels of competence at different times.

All of the concept/process evaluation activities can be carried out with individuals or small groups. Thus, you can use an activity to evaluate just the children for whom you are lacking notes or observations. Some activities also lend themselves to use with the whole class; this is indicated where appropriate.

The activities in this section provide you with ways to evaluate children's understanding of major concepts and processes presented in this unit. Some of the activities will also provide information about understanding of concepts and processes that are of secondary importance in this unit or that were introduced in earlier units.

Keeping records. One side of the Class Profile sheet (Evaluation Materials envelope, drawer 1) provides space to record results of each child's work in each activity. In evaluating children's progress we have found it most useful to distinguish three levels of understanding. These levels, and symbols convenient for recording them, are:

○ **Needs special assistance**
✓ **Check again**
● **Satisfactory**

The symbols have the advantage of being changed easily after a child gives evidence of progress. In addition to the symbol, you may add brief comments in the "Notes" column.

EVALUATION
ACTIVITY

1 Classifying Organisms

SYNOPSIS

After observing different classes of organisms, children identify the classes, sort out organisms according to those classes, and explain the reasons for their groupings.

Administer: ***to groups of 4 to 6 children after Part One***

Suggested time: ***10 minutes for each group***

EVALUATION MATERIALS

For the group:

2 dead plants*
2 living plants*
2 dead animals*
2 living animals*

Drawer 2

2 trays

* provided by the teacher

ADVANCE PREPARATION

Prepare to bring in the dead and living organisms. One living and one dead plant may be of the same kind, and one living and one dead animal also may be alike. Dead animals can be small ones such as flies, other insects, or canned sardines. *Do not* substitute a plastic fish or some other nonliving object for a dead animal.

EVALUATION SUGGESTIONS

Gather four to six children at a table where you have placed the evaluation materials.

Plant and animal. Show the children the collection of living and dead organisms. After they have had ample time to examine the collection, place the plants on one tray and the animals on the other.

- Ask, "How do you think I sorted the organisms?"
- If no one responds ask, "How are these two groups different?"
- Or ask, "How are all of the organisms in each group alike?"

After each child has had an opportunity to answer, direct several convergent questions (similar to those below) to less responsive children, to those who appeared to rely on the ideas of others, and to those whose responses did not include the differences between plants and animals.

- Do these organisms (either group) move by themselves?
- Do these organisms (either group) have legs (roots, flowers)?

If no one has suggested it, ask,

- "Are these plants (or animals)?"

Alive and dead. Rearrange the organisms into two groups—alive and dead. Use one tray for each group.

- As you did before, ask, "How do you think I sorted those organisms this time?"
- For children who do not respond ask, "How do these two groups differ?"
- Or ask, "How are all the organisms on one tray different from those on the other tray?"
- After each child has had an opportunity to contribute his or her idea, direct some convergent questions like the following to less responsive children:

  "Do these organisms *(point to either group)* act differently?"

  "Do you think these organisms *(either group)* can get any bigger? Can have any babies?" And so on.

  "Do you think the animals on this tray *(either group)* will need to eat? To make a home?" And so forth.

  "Do you think the plants on this tray *(either group)* will need water?"

Criteria. Plan to record the outcomes immediately after the discussion. Use the criteria below to help you recall each child's participation in the discussion.

Part A

- Did the child name at least two ways in which plants and animals differ (or in which all plants or all animals are similar)? Appropriate responses might include references to structure ("these all have mouths and those don't"; "these all have leaves sometimes"), references to actions ("this group can move"; "this group can't get up and go"), references to relationships to other organisms ("deer eat these" and "these eat other things like those"; or "these need lots of water and don't eat").
- Did the child, when asked convergent questions, recognize two or more properties that distinguish between plants and animals?

Children meeting either criterion demonstrate a satisfactory understanding of some differences between plants and animals. Children who always echo others may not have a good understanding of the differences between plants and animals, and you may wish to evaluate them separately.

Part B

- Children who named two or more differences between the living and dead organisms exhibit evidence of good ability to distinguish between the two groups.
- Those who think dead organisms can be brought to life by water or food have had insufficient experience with organisms and could benefit from more exposure to plants and animals which are dead or alive.
- Children who do not realize why the objects were grouped as they were are having trouble classifying and need more experiences with sorting.

Follow-up. Many children have simply not had many experiences grouping organisms into categories. Providing these experiences is easy. One direct way is to have the children look through a square meter of lawn or field to find plants and animals that are alive or dead. In cold weather, a bucket full of surface soil from a similar area can be brought to the classroom for sorting. Even magazine pictures can be classified.

Further classification into double categories such as live plants, dead animals, and so on will be helpful for the children.

EVALUATION
ACTIVITY

2 Describing Plant Growth and Development

SYNOPSIS

This activity assesses the children's ability to describe changes in plants as they grow and develop.

Administer: ***to groups of 4 to 6 children after Part Two***

Suggested time: ***10–15 minutes***

EVALUATION MATERIALS

For the group:

assortment of bean, corn, or other plants in various stages of development

Drawer 1

1 set of Squash Life Cycle pictures
1 set of Pea Life Cycle pictures
1 set of Bean Life Cycle pictures

Drawer 2

1 tray

Drawer 5

assortment of seeds

ADVANCE PREPARATION

The pictures showing the squash, pea, and bean life cycles are on white cards. Cut them apart and place them randomly on the tray with the other materials.

EVALUATION SUGGESTIONS

Gather four to six children at a table and give them time to examine the materials. Tell the children you are interested in their observations about plants.

- Ask, "What have you found out about the ways plants change after the seeds have been planted?"
- For children who do not respond, ask, "How have your plants changed while you have been observing them?"
- During the discussion notice which children refer to *growth* ("getting bigger") and to *development*

("growing new things"). Also notice which children spontaneously use some of the following words as they describe changes in their plants: *seed, root, stem, seed coat, cotyledon, leaf, flower,* or *fruit*.

- After each child has had an opportunity to respond to the divergent questions, direct several convergent questions to each child who did not respond, who did not refer to change in size or to new structures, or who appeared to rely on others for ideas. You will notice that each question may be varied as it is repeated for individual children.

  "How does the pea (or squash or bean) change as it grows (or develops)?"

  "Find three (or four or five) pictures that show changes in a bean (or squash or pea) plant."

  "Find pictures that show fruit (or flowers, roots, seeds, or leaves)."

  "Do any (or all) of the plants have roots (or leaves, stems, or flowers)?"

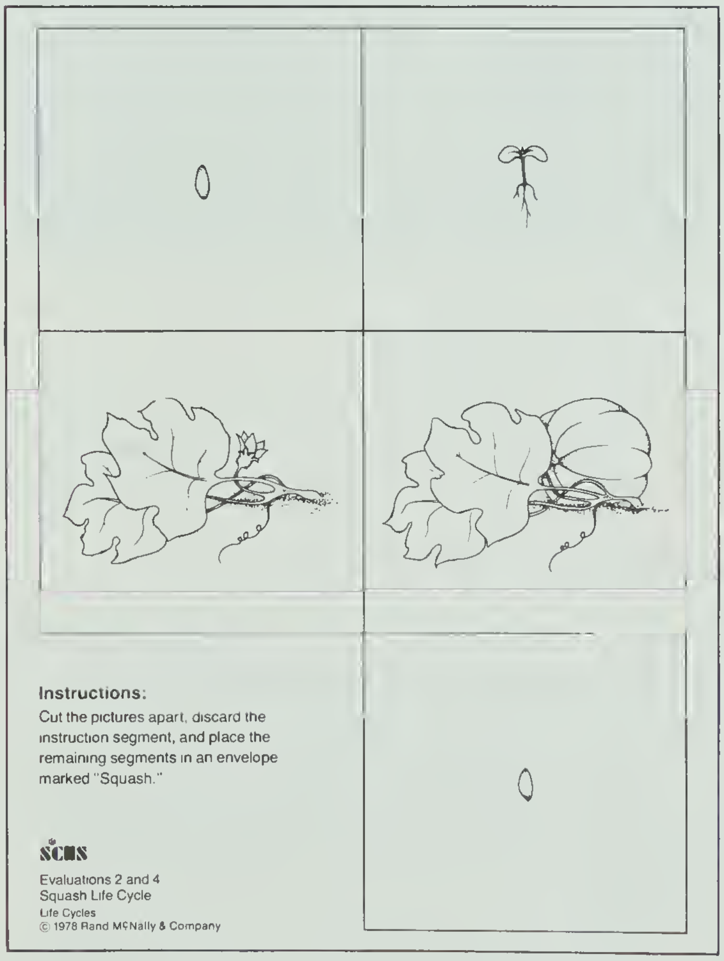
Criteria. Plan to record the outcomes immediately following the discussion, while the children's responses are fresh in your mind. These criteria might help you recall each child's participation:

- Did she describe changes in the size and structure either of plants in general or of her own plants?
- Could he identify plants or pictures that illustrated changes in size or structure?
- Did she spontaneously use some of the following words: seed, root, leaf, flower, cotyledon, seed coat, stem, fruit?
- Could he identify examples of fruit, flowers, roots, stems, or leaves from pictures or from living materials?

Children who meet two of the above criteria have a satisfactory understanding of plant development and growth. Children who meet only one of the above criteria need more experience with plant development. It is most likely that experience in applying the concepts of growth and development to animals will increase their understanding. Children who meet none of the criteria are in need of special attention. Plan to work with them individually in order to identify the causes of their poor performance.

Follow-up. For children who do not understand these concepts, either provide additional experiences of the same kind on a personal level or arrange new kinds of experiences. Sometimes the personal approach solves the problem, but often new experiences

Figure E-1. Squash Life Cycle pictures.



Instructions:
Cut the pictures apart, discard the instruction segment, and place the remaining segments in an envelope marked "Squash."

SCIS

Evaluations 2 and 4
Squash Life Cycle
Life Cycles
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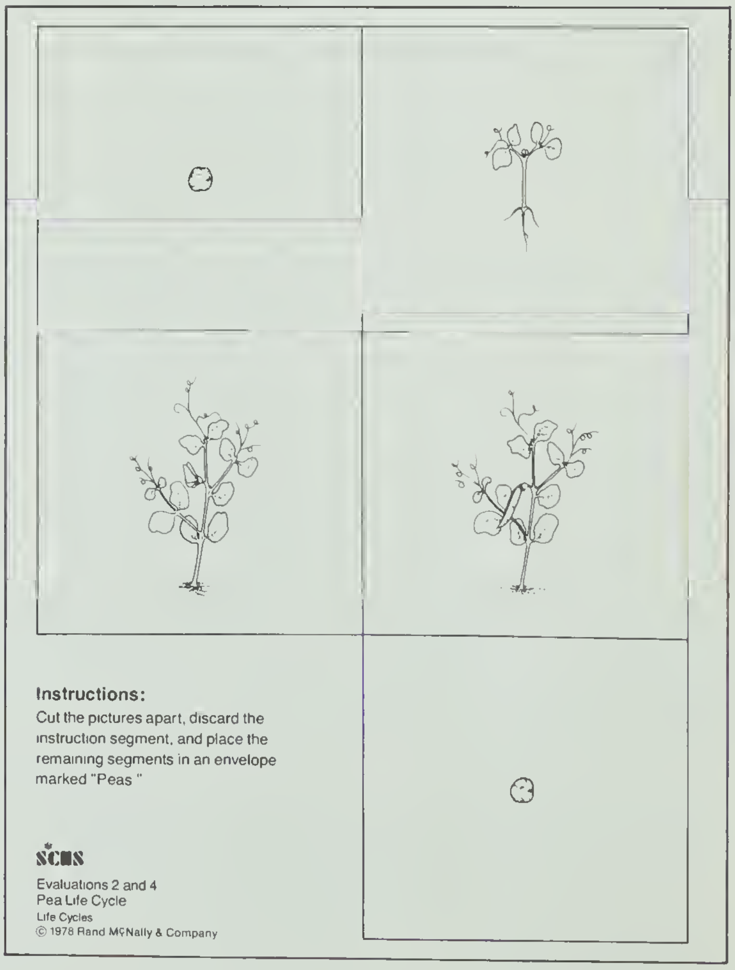
Figure E-2. Pea Life Cycle pictures.



Instructions:
Cut the pictures apart, discard the instruction segment, and place the remaining segments in an envelope marked "Peas "

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Evaluations 2 and 4
Pea Life Cycle
Life Cycles
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coupled with more opportunity for concentration allow the children to grasp the concepts better.

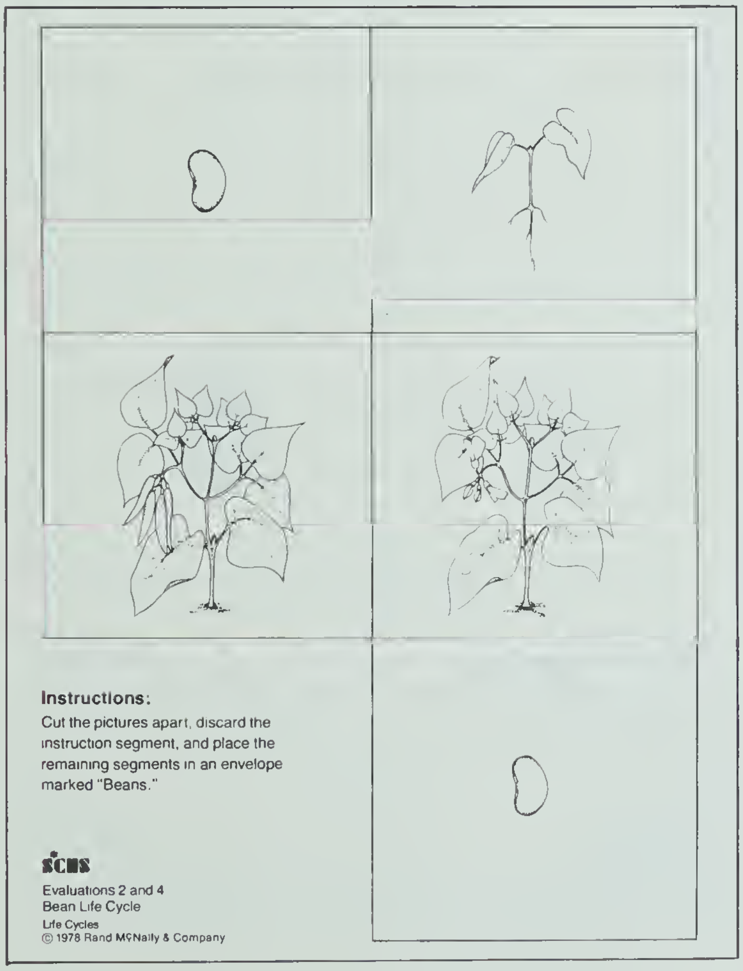
You might take the children for a walk outdoors. This will usually provide you with many opportunities to point out organisms that are smaller or larger than others of the same kind (evidence of growth), and organisms that are in various developmental stages. Any kind of plant or animal will suffice.

To take full advantage of such a field walk, make a game of finding organisms that are of different sizes but are in the same developmental stage—small and large earthworms, for example. This will reinforce the concepts of growth.

For the development concept, the children can look for plants and the seeds which come from them. Or they can look for plants having flowers and similar plants having no flowers. Worm, snail, and slug eggs are often found in soil around flower beds and the bases of shrubs. Various insect stages of development are often obvious, but it is possible that neither you or the children will be able to match the adults with the larvae or pupae.

If you are limited to working inside the classroom, ask the children to draw a picture of some plant or animal. Stop them before they have completed it and explain they are developing the picture. Let them finish it and tell them it is now a fully developed picture. For the growth concept you might blow up a balloon, emphasizing that it is not getting any new parts but is certainly increasing in size (growing).

Figure E-3. Bean Life Cycle pictures.



Instructions:
Cut the pictures apart, discard the instruction segment, and place the remaining segments in an envelope marked "Beans."

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Evaluations 2 and 4
Bean Life Cycle
Life Cycles
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EVALUATION
ACTIVITY

3 Describing Animal Growth and Development

SYNOPSIS

This activity assesses the children's ability to describe changes in animals and to discriminate between growth and development.

Administer: *to groups of 4 to 6 children after Part Four*

Suggested time: *10–15 minutes*

EVALUATION MATERIALS

For the group:

1 tray containing:
  1 or 2 petri dishes with all available stages of the mealworm life cycle
  1 or 2 vials with all available stages in the fruit fly life cycle
  1 aquarium containing tadpoles

Drawer 1

1 set of Frog Life Cycle pictures
1 set of Fruit Fly Life Cycle pictures
1 set of Wax Moth Life Cycle pictures
1 set of Mealworm Life Cycle pictures

NOTE: If the children have not yet seen the adult stage of the mealworm beetle, *do not* use the mealworm life cycle pictures in this evaluation.

ADVANCE PREPARATION

The pictures showing the frog, fruit fly, moth, and mealworm cycles are on white cards. Cut the pictures apart and place them randomly on the tray with the other materials.

EVALUATION SUGGESTIONS

Gather four to six children at a table and give them time to examine the materials you have assembled. Tell them that you are interested in their observations about animals.

- You might ask, "What have you found out about how animals change as they grow and develop?"
- For children who do not respond, ask, "How have your animals changed while you have been observing them?"
- During the discussion, notice which children refer to growth and development. Also notice which children spontaneously use the words *egg, larva, pupa,* and *adult.*
- After each child has had an opportunity to respond, direct several convergent questions to each child who did not respond, who did not refer to changes in size and structure, or who appeared to rely solely on the ideas of others.

  "How does the frog (or other animals) change as it grows (or develops)?"

  "Find three (or four or five) pictures that show changes in the mealworm (or fruit fly or frog)."

  "Find the adults (or the eggs, pupae, or larvae)."

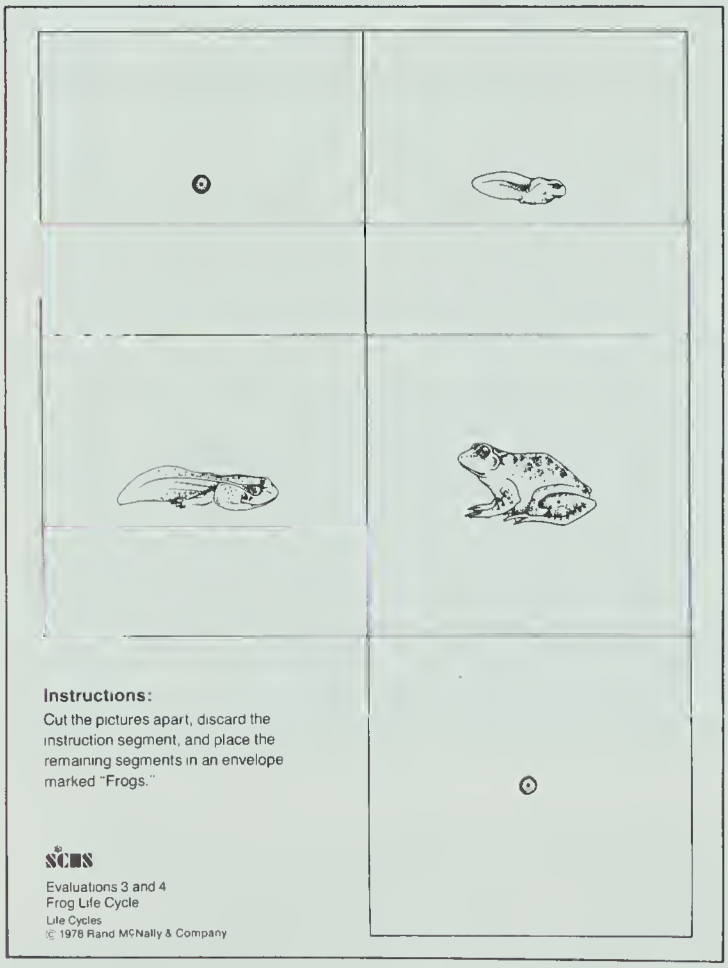
  "Describe the frog (or other animal) after it comes from the egg."

Criteria. Record the outcomes immediately after the discussion. The following criteria might help you recall each child's participation:

- Did he describe changes in the size and structure either of animals in general or of his animals?
- Could she identify animals or pictures that illustrated changes in size and structure?
- Did he spontaneously use the words egg, larva, pupa, and adult?
- Could she identify examples of eggs, larvae, pupae, and adults from pictures or from living materials?

Children who meet two of these criteria demonstrate a satisfactory understanding of the growth and development of animals. Children who meet only one of the criteria may have misconceptions which can be clarified. Spend a minute with them individually and ask them one or more questions similar to those above. Children meeting none of the criteria will need special help.

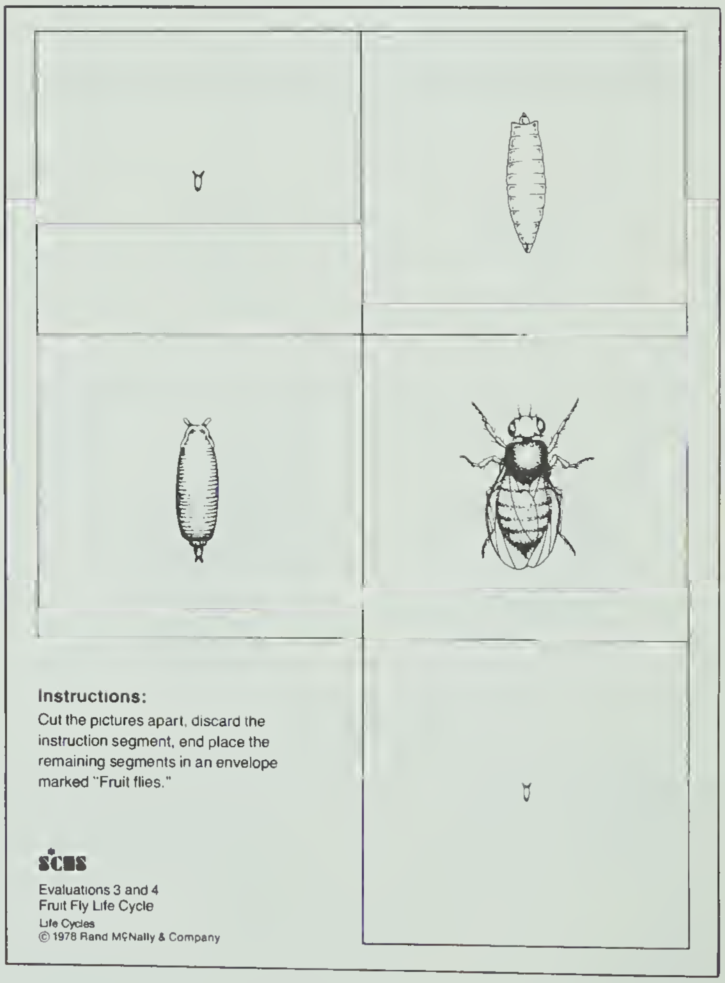
Figure E-4. Frog Life Cycle pictures.



Instructions:
Cut the pictures apart, discard the instruction segment, and place the remaining segments in an envelope marked "Frogs."

Evaluations 3 and 4
Frog Life Cycle
Life Cycles
© 1978 Rand McNally & Company

Figure E-5. Fruit Fly Life Cycle pictures.



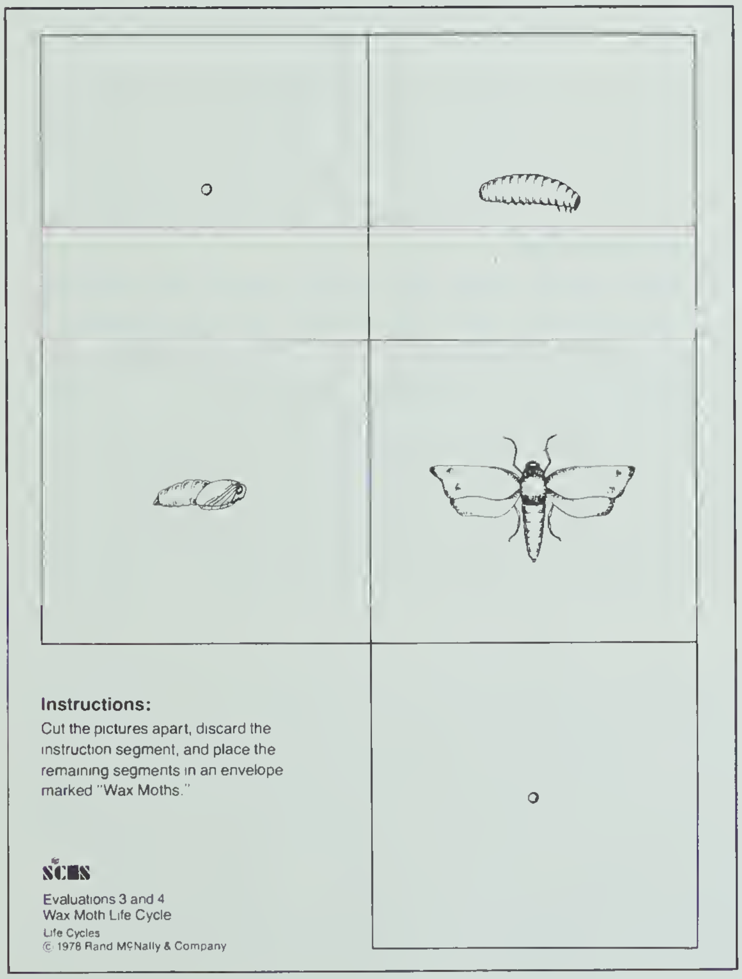
Instructions:
Cut the pictures apart, discard the instruction segment, end place the remaining segments in an envelope marked "Fruit flies."

Evaluations 3 and 4
Fruit Fly Life Cycle
Life Cycles
© 1978 Rand McNally & Company

Follow-up. For children who have difficulty with these concepts, play a game in which one student describes a life cycle stage of any familiar animal, and the other children try to determine which stage is being described. The children may take turns offering clues and trying to guess the stage. As the children improve in their ability to discriminate between stages, less-familiar organisms may be described.

To help an individual child, have him or her review the various animal stages using both the live animals in the classroom and the cards in the equipment kit. Many nature books and magazines have pictures of various organisms' life cycle stages. Certain children may be more interested in studying large drawings of mosquito stages, for example, than in living animals. The particular animal for which you can find life cycle stages is unimportant. However, you can help the students most if you describe the common characteristics of all eggs (rounded, usually light-colored, smaller than the next stage, nonmoving), larvae (usually longer than wide, active, eating most of the time, rapidly growing), pupae (often in a cocoon or other wrapping; quiet, not eating), and adults (usually moving, usually the largest stage, usually having more parts or colors than other stages).

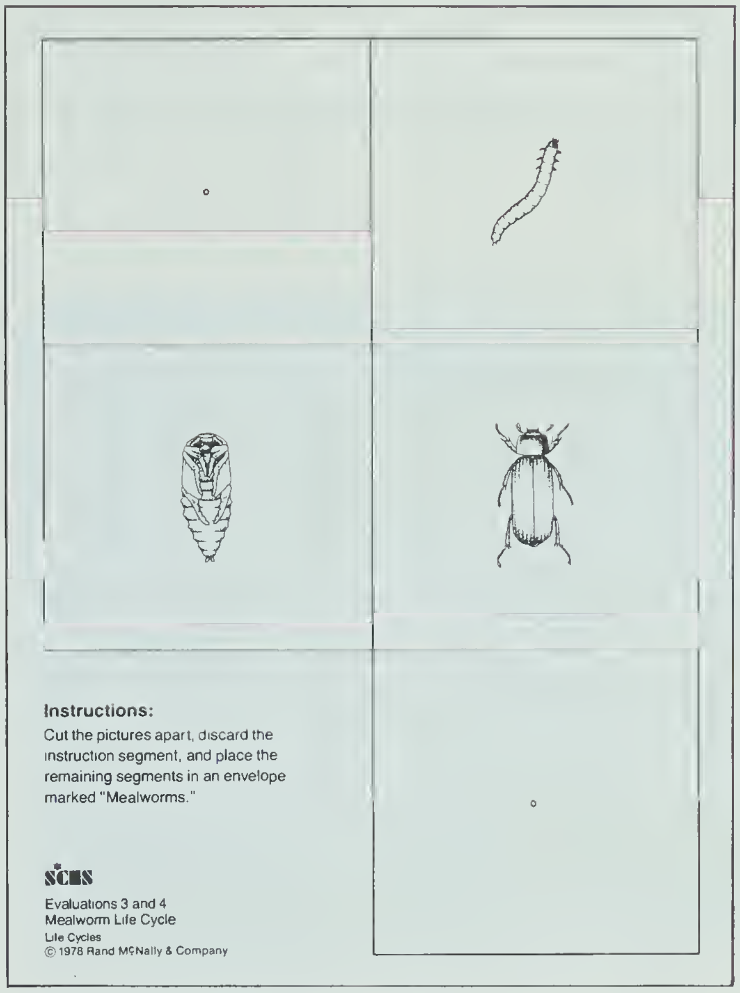
Figure E-6. Wax Moth Life Cycle pictures.



Instructions:

Cut the pictures apart, discard the instruction segment, and place the remaining segments in an envelope marked "Wax Moths."

Evaluations 3 and 4
Wax Moth Life Cycle
Life Cycles
© 1978 Rand McNally & Company



Instructions:

Cut the pictures apart, discard the instruction segment, and place the remaining segments in an envelope marked "Mealworms."

Evaluations 3 and 4
Mealworm Life Cycle
Life Cycles
© 1978 Rand McNally & Company

Figure E-7. Mealworm Life Cycle pictures.

EVALUATION
ACTIVITY

4 Recognizing Stages in Life Cycles

SYNOPSIS

This activity assesses the children's ability to sequentially arrange pictures of stages in the development of organisms and to recognize the sequence as a life cycle.

Administer: *to groups of 2 or 3 children after Part Four*

Suggested time: *15–20 minutes*

EVALUATION MATERIALS

For the group:

sets of life cycle pictures (from Evaluations 2 & 3)

ADVANCE PREPARATION

The Life Cycles game is described below in two versions. Both versions of the game evaluate the players' ability to (1) identify pictures that illustrate the life cycle stages of a particular organism and (2) arrange these pictures in correct sequence. In the first and simpler version each player is given two complete sets of pictures to order; in the second version he or she must acquire the sets of pictures by drawing them from a common pool or by trading with other players. Though the second version is more motivating for some pupils, it is more threatening to others. Read the descriptions of the two versions below and decide which to introduce to each group.

EVALUATION SUGGESTIONS

Introduce either version of the Life Cycles game to a group of two or three children. Have them sit with you at a table.

First version. Give each player two different sets of life cycle pictures. Tell each child to put his or her pictures face down and mix them by moving the pictures around on the table. Tell the group that on your signal the players should turn their picutres face up and arrange them in the proper sequence to form a life cycle. The game ends when all children have arranged their pictures. The winners of the game are the players who correctly complete both of their arrangements.

During the game, look for children who have difficulty arranging their pictures. This may indicate that they do not recognize all of the pictures belonging to a particular set or that they are still unfamiliar with the appropriate sequence of stages for a particular organism.

At the end of the game, ask the children to check each other's arrangements. Disagreements may arise over the correct order. Listen carefully to the reasons children give each other for their arrangements, and note which children still do not understand the sequence of stages illustrated.

Repeat the game two or three times for each group, with players using different sets of pictures.

Second version. Have the children place six sets of pictures face down in a common pool in the center of the table. All players help mix the cards by moving them around. Designate one child to start first. That player chooses any picture and places it face up in front of him. The other players take turns repeating this procedure. Players continue accumulating pictures in front of them. When any player completes a life cycle—acquires all of the pictures of the stages of any plant or animal—and arranges his pictures in proper sequence, he says "Life Cycle!" He then moves the set to one side. The game continues until all of the pictures have been chosen. The children will have to trade various pictures with each other for mutual advantage.

As each group plays this game, watch for children who prematurely call "Life Cycle" or who acquire a life cycle without recognizing it. Such children may be uncertain about the number of stages they need to complete a cycle (five pictures) or fail to recognize the picture of a particular stage. When a game ends, encourage all players to check each other's cards for completeness and sequence. As in the first version, disagreements may arise. Listen carefully to the reasons children give each other for their arrangements.

Criteria. Children who can arrange two sets of pictures in appropriate sequence demonstrate satisfactory achievement. If you are uncertain about a particular child's understanding (if she arranges only one sequence appropriately), include her in another group or play a short game with her individually. Children who consistently fail to arrange sequences appropriately have not understood the life cycle concept and are in need of special help.

Follow-up. If you still have any animals present in all phases of their life cycle (or even in early stages, such as eggs or larvae) give some to the children. If you have none, buy some at a pet store or dig some from a flower bed. These animals can become the personal property of these children. Provide containers and labels.

Ask each child to sort the stages into similar groups, placing all larvae in one container labeled Larvae and doing the same for the other stages. Prepare a container and label for each group.

Add food and moisture as necessary, making sure there is sufficient air in the containers.

The student should report to you whenever any of the animal stages changes. At that time, ask the pupil to remove the animal that changed from its container and to place it in the appropriately labeled container. In this way you will be able to see if the student is having trouble and why. Seeing the terms used on the labels and talking about them with you will familiarize the children with the words.

Attitudes in Science

These comments are designed to help you assess four major attitude areas that can indicate developing scientific literacy in children.

When using this phase of evaluation, keep in mind the question "In what ways is the child behaving like a scientifically literate individual?" During your day-to-day science teaching, look for evidence of positive attitudes in the following areas:

Curiosity. Children who pay particular attention to an object or event and spontaneously wish to learn more about it are being curious. They may give evidence of curiosity by—

- using several senses to observe organisms and other objects
- asking questions about objects and events
- eagerly examining organisms, equipment, or other materials at the time they are first distributed
- showing interest in the outcomes of experiments

Inventiveness. Children who generate new ideas are being inventive. These children exhibit original thinking in the interpretation phase of an activity. They may give evidence of inventiveness through actions or verbal statements by—

- using equipment in unusual and constructive ways
- suggesting new experiments or
- describing novel conclusions from their observations

Critical thinking. Children who base suggestions and conclusions on evidence are thinking critically. They may exhibit critical thinking largely through verbal statements by—

- using evidence to justify their conclusions
- pointing out contradictions in statements by others or
- changing their ideas in response to evidence

Persistence. Children who maintain an active interest in a problem or event for an extended period of time are being persistent. They are not easily distracted from the subject at hand. They may give evidence of persistence by—

- continuing to investigate materials after the novelty has worn off
- completing an activity even though their classmates have finished earlier or
- redoing an experiment while making some manipulative or procedural changes in order to improve the results

Of course, the behaviors related to these areas are not restricted to science; they may be observed in other curriculum areas when suitable opportunities exist.

Observing a whole class busily engaged in diverse activities makes attitude-evaluation of individuals virtually impossible for one teacher. We recommend that you focus your attention on attitudes demonstrated by four or five children during each session. You may do this by following an alphabetical class list or by concentrating on one or two teams per session. If you learn something about four or five children during any one session, then you will be able to make a note about each child four or five times in the teaching of one SCIIS unit. Active, vocal children will gain your attention more frequently; quiet children may escape your notice for some time. Adopting a plan for observing class members ensures that you will not overlook any individuals.

In addition to observing the children, an effective way to measure attitudes is to ask divergent questions about the work they are doing (see page 00). By listening carefully to their responses, you will obtain significant feedback regarding their attitudes.

Keeping records. Space is provided on one side of the Class Profile sheet (Evaluation Materials envelope, drawer 1) for recording observations about each student's attitudes four times during the unit. In the "Notes" column, you may include a short statement indicating what you observed each time the child was selected. Many teachers make their notes while the children are cleaning up at the end of the activity.

The use of this informal but organized assessment system will provide you with a great deal of information about the children's development and will assist you in planning for effective instruction in science.

Perception of the Classroom Environment

This activity indicates how the children assess the nature of the classroom during science—or how they would like it to be. The activity answers the following questions:

- Do the children see science class time being used in the way you intend it to be used?
- Do they feel that they are active participants in science class?
- Which kinds of science activity—experimenting, writing or drawing, listening to the teacher, discussing, or reading—do they generally prefer?

Young children are sensitive to suggestions from adults. To avoid unduly influencing pupils' perceptions of the classroom, you must be completely noncommittal about what you think is most important or most interesting.

In our experience, most children prefer experimenting, but some do prefer to read or listen to the teacher. Certainly all five kinds of activity are important in a balanced science program, and they should be combined in a way that benefits children most. In field tests of these materials, teachers reported that they could anticipate many children's responses, but that there were usually a few whose perceptions or preferences surprised them and helped them to adjust their teaching accordingly.

The following activity has been written in a style similar to that of the regular SCIIS activities in the hope that the children will see it as a natural part of the learning sequence rather than as a formal examination. The activity may be used at the end of each Part in the unit.

Our Science Class

SYNOPSIS

Children use a chart to indicate (1) how they think science class time was used or (2) which kind of science activity they prefer.

Administer: *to entire class at conclusion of each Part*

EVALUATION MATERIALS

For each child:

small piece of paper*

For the class:

Drawer 1

Our Science Class chart

* provided by the teacher

EVALUATION SUGGESTIONS

Post the chart in a prominent place and tell your pupils that the pictures show what might go on during a science session. To make sure they can interpret the pictures correctly, invite them to find the pictures that show children (1) experimenting, (2) writing or drawing, (3) listening to the teacher, (4) discussing, and (5) reading.

Distribute the papers and tell the children to write their names on the papers. Then ask them to write the number of the picture that shows what happened *most* during the science session on that day (or during the last week). Some children may wish to write more than one number. Tell them they may choose two pictures; listing more than two is less effective.

Collect the papers. Did the class express a consensus? Compare the results with your own impressions. If you find that most pupils identified the picture of children listening to the teacher (3), they may feel they were not active participants in the discussion.

If many or most of the children perceive a different emphasis than you intended, review "Helping Children Learn with SCIIS" and the "Teaching Suggestions" in the next few chapters, to help you plan future science periods.

You may also use "Our Science Class" to assess the children's preference among the different kinds of activities. To do this, ask them to identify the picture that shows the kind of activity they like best.

Glossary

The definitions in this glossary are intended for your use and quick reference. We do not recommend that you use them verbatim to answer children's questions.

aged tap water – tap water that has been standing in an open container at least two days, allowing chlorine to escape.

animal-eater – an animal that uses other animals as a food source; usually a predator.

aquarium – a container of water in which water-dwelling plants and animals live.

aquatic – living in water.

bacteria – a group of microscopic organisms. Some are decomposers that break down feces and dead organisms, resulting in their decay. Bacterial action can often be recognized by a foul odor.

birth – the coming into being of a new individual organism.

characteristics – distinguishing features or qualities.

controlled experiment – an experiment consisting of at least two setups that are alike in all ways but one—the variable whose effect is being investigated.

cotyledons – the large portions, excluding the embryo, of seeds. Cotyledons contain stored food used by the embryo for its initial growth.

death – the end of life.

development – passage from one state of maturation to the next, recognized by the appearance of new structures such as flowers on pea plants. (See *growth.*)

egg – the female reproductive cell, which usually must be fertilized in order for offspring to be formed.

embryo – an organism in the initial stages of its development.

environment – the combination of all external factors that affect and influence the growth, development, and reproduction of organisms.

evidence – an observable effect that is used to make decisions.

experiment – to test or try in order to answer a question.

feedback – information that comes to a person as a result of something done by that person. A child's answer to your question provides you with feedback about earlier instruction.

fertilization – the union of sperm and egg cells that initiates the development of a plant or animal embryo.

flower – the reproductive structure of a seed-bearing plant, within which fruits begin to form.

food – that which is manufactured by plants and then is used by animals for nourishment.

food chain – a concept that can be diagramed to depict the food relations among plants, plant-eaters, and animal-eaters. For example: wheat →crickets→frogs→raccoons. A food chain may consist of only a plant population and an animal population that eats it. For example: corn→ humans.

fruit – the ripened ovary or ovaries that develop from a flower and contain seeds.

genetic identity – the similarity between parents and their offspring due to the transmission of distinguishing characteristics.

germinate – to begin to grow; to sprout.

growth – increase in size. (See *development.*)

habitat – the place in the environment where a particular organism normally lives.

larva – the first stage after hatching of any animal that undergoes metamorphosis, such as a tadpole. In insects the larval form is often wormlike.

leaf – one of the expanded, usually green, organs borne by the stem of a plant.

life cycle – the sequence of changes as an organism develops from an egg to an adult, which in turn produces eggs or sperm that give rise to the next generation. For example, the mealworm life cycle includes egg, larva, pupa, and adult that produces eggs or sperm.

metamorphosis – in animals having decidedly different life cycle stages, the change from one to the next.

minerals – naturally occurring inorganic substances. Minerals in the bodies of dead organisms are released to the soil by decomposers and are used by plants.

mold – a kind of decomposer characterized by a fuzzy appearance. Molds may be any of several different colors.

molting – the shedding of skin, feathers, or hair by animals.

nonliving – any object not now alive or previously alive.

organism – an individual living thing; any plant or animal.

photosynthesis – the process by which green plants manufacture food from water and carbon dioxide, with sunlight as the source of energy.

plant-eater – an animal that uses plants as a food source.

pupa – the transition stage of insect metamorphosis, between larva and adult, of many insects that undergo metamorphosis. The animals in cocoons and chrysalids are pupae.

reproduction – the process by which new members of a species are produced.

root – the part of a plant that grows downward in the soil and through which the plant obtains water and minerals.

seed – an immature plant that can grow into a mature plant if environmental conditions are suitable.

seed leaf – a cotyledon that is still attached to a seedling.

seedling – a young plant that emerges from a seed.

stem – the part of a plant that grows upright and supports the leaves, flowers, or fruit.

SCIIS Plants and Animals

The organisms used in the SCIIS life science units have been chosen for their resiliency and ease of maintenance as well as their behavior, feeding relationships, and life cycles; no complicated feeding or housing arrangements are required. Nevertheless, some preparations for the arrival of organisms are necessary. Aquatic organisms, for instance, need aged tap water, in which the chlorine content is reduced below the level that is harmful to the organisms. Terrestrial organisms need a container with plants or animals that serve as food. On the following pages you are given both background and maintenance information on the plants and animals studied in this unit, as well as general information on planning and ordering procedures.

PLANNING THE UNIT SCHEDULE

Living organisms are the focus of the children's investigations in the SCIIS life science units. Ordering and maintaining the organisms during the teaching program are therefore important responsibilities for you and your pupils.

In planning to teach a life science unit, first examine the "Schedule of Activities" on the last page of this Guide. The schedule identifies the activities in the unit and indicates the approximate time required for each one. Also indicated are the times when organisms should be ordered. Use the schedule along with the following instructions to make sure that you receive living organisms when you need them.

ORDERING LIVE ORGANISMS

The seeds and live organisms for SCIIS are to be obtained through Rand McNally & Co. In each kit you will find an envelope containing one or more forms to be used in ordering the organism shipments.

What to order. The contents of the Life Cycles Shipments are as follows —

LC-1: Frog eggs, cricket eggs, tadpole food, cricket food.
LC-2: Fruit fly larvae, wax moth larvae, wax moth food.
LC-3: Small and large mealworm larvae, a mealworm food, butterfly larvae, butterfly food.

When to order. As you proceed through the Teacher's Guide, watch the "Getting Ready" notices — you will be reminded to send in each order form well in advance of the time when you will need the shipment. It is very important to you and the children that the organisms arrive on time: *You must make sure that the order is mailed three weeks before the shipment is needed.* This is because the supplier not only must process the order, package the shipment, and allow time for shipping, but in some cases must also assist the animals. For example, the frog eggs in *Life Cycles* must be squeezed out of females, fertilized by sperm, and checked for viability just before shipment. Other organisms must be carefully selected so that they will be the correct age and size and in proper condition for use in the classroom.

How to order. Complete the order form for the shipment, including the date when needed, your name, and the school's exact address. Do *not* have these shipments sent to your district's central supply department or warehouse! The arriving organisms will need your care immediately and must not sit on a shelf. To prevent your shipment from being treated casually when it arrives at your school, forewarn the mail or package sorter of its impending arrival and firmly request that you be notified as soon as it is received. Too many organisms have died in their shipping containers after languishing for a week under a counter only a few doors away from the waiting children.

Preparing for arrival. The preparations necessary for SCIIS organisms are minimal, but they are important. The sooner you can get the organisms out of their shipping containers and into their proper habitats, the better for the organisms.

Before any organisms arrive, tell the children that in handling the plants and animals, they should be as careful as they would be with their own pets. No SCIIS organisms will hurt them, but the children should keep their hands away from their faces while working with the organisms and wash their hands afterward.

Water. Water to be used in aquariums can usually be taken from the tap, but you should not put organisms into tap water immediately. "Age" it by leaving it uncovered for at least two days to allow the chlorine to escape. If you age water in 1-gallon jugs with small necks, be careful not to fill the jugs completely, or the water's top surface area will be too small for rapid exchange of gases. To begin *Life Cycles* you will need to age 15 liters (3½ gallons) of water in the aquariums.

Another source of water is spring water from a grocery store or a bottled water company. Do not confuse spring water with distilled water — they are different! We do not advise using distilled water, because it is not supposed to contain any chemicals other than pure water. All animals need certain elements that are always present in spring, pond, or tap water.

The frog eggs are very sensitive to chemicals that may be in water. To be successful with these organisms, take the time to read the following paragraphs and to locate a source of water if that in your school is unsatisfactory. There is scarcely anything as sad as the disappointment of thirty second-graders whose frog eggs didn't hatch.

Your decision about whether your water is satisfactory for maintaining frog eggs must be based upon past experience in your school. You can't experiment with the frog eggs after they arrive, because you risk losing all of them in any experiment. Instead, find out if any teachers have used the school's water for an aquarium. If they have successfully used school tap water for raising small fish, then your water is probably fine for frog eggs also. If they had to age the water or chemically dechlorinate it for fish, then you should age the water to be used for frog eggs.

If you have any doubts about the suitability of your water supply, don't use it for frog eggs. Instead, locate a pond, lake, marsh, or river in which you know animals are living. Using clean containers, collect enough of that water to start all of your frog aquariums. As the water evaporates, supplement it with aged tap water.

Sand and soil. These items are provided with the equipment kit and have been carefully chosen for suitability with the organisms and equipment in the program. Sand to be used in an aquarium must be rinsed of dust so the aquarium water will remain clear: half-fill an aquarium with sand, add water while stirring the sand, and pour off the cloudy water. Continue flushing the sand with water and discarding cloudy water until the water remains clear after the sand has settled. Distribute the washed sand to other aquariums.

The soil has been pre-mixed in the proper proportions for good growth and drainage, and it needs no further preparation.

Plants. In some units, arriving terrarium animals should have growing plants waiting for them. No terrariums are used in *Life Cycles,* but you may need to construct one for some related activity. Be sure to plant seeds at least a week before adding animals in such cases.

PLANTING SEEDS

The seeds are shipped with the kit and are available for your use as soon as you wish to begin the unit. You are probably familiar with the kinds of seeds used in SCIIS.

No seeds in the program contain toxic materials, nor are they coated with such materials. Because children may put seeds in their mouths, you should avoid using seeds sold for garden use, which may have been treated with toxic chemicals to retard mold growth. The SCIIS seeds have been selected for high viability: nearly all of them will germinate if they are planted and watered properly.

The only common classroom problem children have with seeds is that the seeds do not germinate. This is often caused by excessive watering. Not watering will of course also result in no germination, but that problem is unlikely in a classroom.

CARE OF PLANTS IN THE CLASSROOM

A classroom isn't always the best environment for plants. Your room may be very dry, cold, hot, bright or any combination of factors. But by concentrating on the three environmental factors over which you can have some control — water, light, and temperature — you will have success with the plants we have selected.

Before beginning the unit, decide where you will grow the plants, keeping in mind the amount of light, temperature, and drafts. Also consider whether the plants will be bumped into often, and if the children will be able to observe them easily. Using the following list will help you find the best place for your plants and to give them good care.

Water.

- The amount of water is the *most* important environmental factor for plant development and growth. While classroom temperature and light variations can speed up or slow development and growth, excessive water variations quickly *kill* plants. A fast- or slow-developing plant is infinitely better than a dead one!
- Use enough water to darken the soil. The soil is too wet if (1) you can squeeze water from a large pinch of soil, (2) you can see water in the planter base, or (3) a seed rots.
- The soil may be too dry if (1) a pinch of soil crumbles, (2) the seeds in it don't sprout, or (3) the seeds in it sprout later than the seeds planted in wetter soil.
- We can give no prescription for how much water should be given, or how often. Each classroom is different, and you must watch your plants' soil.
- The heat and low humidity in some classrooms cause plants and soil to dry out very rapidly. In such rooms avoid placing the plants in any drafts.
- For vacation periods place all the plants together, water liberally, cover with a large plastic sheet (a drop cloth or dry cleaner's bag), and leave the light source on (outside the plastic sheet) to help maintain the temperature about 10°C (50°F). Tell the custodian to leave the light on.

Light.

- Light is not needed until plant parts emerge from the soil.
- After emergence, the equivalent of a 100-watt bulb about 80 cm from the plant is sufficient for good growth.
- To estimate the proper height of the light source above the plants, hold your hand next to the plants. If the light shining on the back of your hand feels uncomfortably warm, raise the bulb. If your hand feels cool, lower the bulb.
- The light source supplied in the kit is adjustable.

A CHECKLIST OF PLANT PROBLEMS

Failure of seeds to develop.

___ Too much water causes rot. Dig up one seed. If it is rotten discard the seeds, let the soil dry out, and start over.

___ If too little water has been added, the seeds will be unchanged from when they were planted. Water the soil thoroughly after replacing the seeds, and be sure they are not receiving too much heat.

___ You may not have waited long enough. Some seeds are slower to develop than others, though the kinds of seeds provided in the kits should sprout within nine days. Seeds will develop slowly if they are cold or haven't received enough water.

___ The seeds may have been planted too deeply, or the soil may have been pounded down on top of them. If you think this is the problem, dig the seeds up and plant them again.

___ In any group of seeds, a few will fail to develop. Assume 9 out of 10 seeds planted will develop, and be sure the children plant enough seeds to allow for this.

Animals on the plants or soil.

___ This usually occurs in overwatered plants. Reduce the amount of water given, and be sure none is standing in the planter bases.

___ Animals are free sources of live organisms—use them. They probably will show different life cycle forms. Aphids and gnats are common and will reproduce on plants and soil.

Blemishes.

___ Symptoms such as discolorations, leaf curl, and fuzzy spots on soil or plants are probably caused by molds or other fungi. Dry the plants out by watering them less and increasing the amounts of light and heat they receive.

___ Blemished plants will not necessarily die. To prevent infection of healthy plants, isolate the infected plants until they recover.

Breakage.

___ Protect plants from breaking by storing them where the children are not likely to knock them over or brush against them.

___ Allow only a few children to retrieve their plants at a time. This reduces jostling that might otherwise occur.

___ Encourage children to be gentle with the plants as they work with them.

___ Avoid storing plants near windy doorways or windows, where they might be blown over.

___ Use support sticks and ties for tall plants grown in pots.

Miscellaneous problems.

___ Sick-looking or dead plants may have lost too much water over the weekend. The solution is to water plants more on Fridays, or to cover them with waterproof plastic wrap, being careful the plastic does not break them.

___ Diseases are possible, but unlikely. Discard any diseased plants and plant new seeds.

___ Weak stems are usually caused by an overabundance of water, by the addition of more soil after the plant has sprouted, or by insufficient light. Have the children use less water, support the plants with sticks and ties, and be especially careful with these plants.

___ Kinked stems can be salvaged if they are kept straight with splints. Use yarn, tape, or a twistem to attach a stick or pencil to the weakened section of the stem.

Use this feature for altering both the light intensity and the temperature.

- Whether the light is from sunlight or from the light source in the kit, the plants in this unit will grow. Natural light is better than artificial unless you have so much sunlight that the soil and plants dry out or become too warm. A table or shelf near the windows, but not in the draft of the heater or air-conditioning fan, is a fine place for storing plants.
- Windowsills are often problem spots. Depending on the time of year, they may be too hot, too cold, or too windy; or the shades and curtains may knock over the plants.

Temperature.

- 15–35°C (59–95°F) is the acceptable range. However, 20–25°C (68–77°F) is best.
- If you use the light source provided in the kit remember that whenever the plant is receiving light it is also absorbing heat from the bulb, and the plant may be much hotter than the room. Adjust the lamp height as necessary.
- The heat from any source of light may cause the soil to dry out, which is critical. Water is more important to plants than either light or temperature.

Possible plant problems. In spite of your conscientious care, you may have trouble with seeds or plants. If you do, use the checklist on the facing page.

CARE OF ANIMALS IN THE CLASSROOM

All the animals selected for use in this program will live in your classroom. However, we often find variations among classrooms that can cause some problems. Your room may be too dry, cold, bright, or hot for some of the animals. In many schools the heat is turned down at night and on weekends; some schools are dark; in others the blinds must be pulled down every afternoon; and some are in areas of very low or high humidity. Some rooms with a southern exposure heat up. Rooms with windows on the west side may have bright sunlight at four or five o'clock, after everyone has gone home — everyone but the SCIIS organisms, which then find themselves literally in hot water. The next morning the water has cooled and everything looks normal, but many organisms are dead.

To prevent such disasters and the resulting disappointments for the children, set aside ten minutes to read the section beginning on page 110, describing the key points in maintaining each of the animals. Environmental factors which can severely affect classroom animals are water, light, temperature, and food.

Water.

- Frogs must have nearly full cups of water *at all times*.
- Cricket eggs must be kept moist.
- Crickets must have access to water droplets every two days, but there should be very little water in the soil in which they walk. Use the water sprinkler to spray water on the container walls.
- Fruit flies and moths should not be given water at all.
- Mealworms should be given pieces of potato or apple for moisture. Replenish when the potato or apple has become dry or every four days, whichever happens first.
- Caterpillars usually get moisture from the leaves they eat. However, it is advisable to sprinkle a small amount of water on the leaves every other day.

Light and temperature.

- The presence or absence of light alone will not harm your animals. However, the light source also gives off heat that builds up inside containers.
- Check the temperature with the back of your hand, as described on page 107.
- For each animal there is an optimum temperature, but none of the animals supplied will be harmed if you keep the temperature between 10°C (50°F) and 25°C (80°F).
- Temperatures below 23°C (75°F) will tend to slow the rate of development a little. But as with plants, an organism that develops too slowly is far better for your purposes than a dead one.
- When in doubt about whether to raise the temperature another degree or two, ask yourself whether there is danger of raising it too much if you forget to monitor the increase. If so, do not try to raise the temperature. Remember, this unit *cannot* be taught without live organisms.

Food. You really can't overfeed the animals in this unit, but you can provide so much food that it is left to spoil

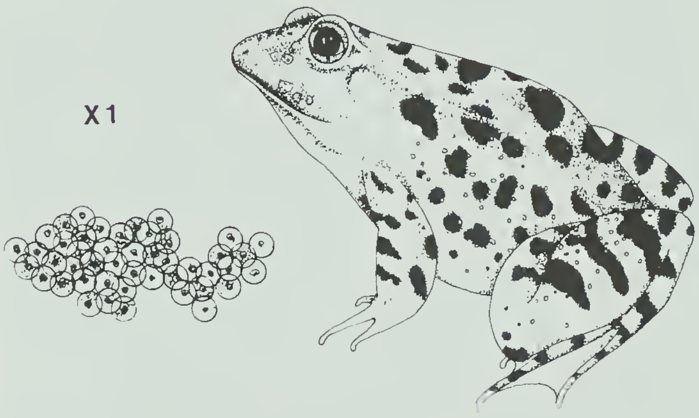
- No more than one food pellet should be in a child's container of tadpoles or frogs at any one time. Your large aquariums can have two or three pellets on the bottom at one time.
- Crickets, fruit flies, moth and butterfly larvae, and mealworms should always have excess food available.
- If the mealworm food becomes moist, it will spoil and harm the mealworms. Exchange any moist food for dry.

PLANT AND ANIMAL SHIPMENTS FOR *LIFE CYCLES*

Frog eggs.

Receiving the organisms. You receive frog eggs in Live Organisms Shipment LC-1. Open the container of frog eggs immediately. You should have prepared water in advance. Lower the container of frog eggs into some of the prepared water and leave it there one hour, so that the eggs will gradually change in temperature. Then, if you cannot dispense the eggs to the children immediately, discard most of the water in which the eggs arrived and carefully pour the egg mass into your prepared water container.

Figure L-1. Frog and frog eggs.



You may snip the eggs apart now according to the directions in Chapter 9, or you may wait until you begin that chapter. Any scissors will do, but they should be washed in clear water just before you cut the egg mass apart. The likelihood of cutting eggs in half while separating the egg mass is quite remote because the eggs tend to slide out of the way.

Do not add any food or other material to the water in which you store the eggs. If you store them in the prepared water container, keep them out of bright sunlight and excessive heat.

The frog eggs will mature into tadpoles within about two to five days. (Frogs spend only a short time in the egg stage, and they have been in transit for up to three days since they were laid.)

Classroom care and maintenance. The following measures can be taken to insure the survival of your frog eggs:

- Use prepared water, described in the section entitled "Water" (page 106).
- Do not store the eggs in direct sunlight.
- Maintain the temperature between 20 and 30°C (68 and 86°F).
- Remove any eggs that appear dead or moldy.
- Change the water in the containers weekly if that is possible.
- Feed tadpoles only as much as they eat in a day. Feed every other day, except weekends.
- When the tadpoles become farily large, remove some in order to provide more space for the others.

Description and natural history. In the fall and spring of each year, frogs lay their eggs in still ponds or other bodies of fresh water. Many of the eggs, which are in large masses of jellylike material, are eaten by fish, crayfish, and similar animals. The eggs that develop into tadpoles also are preyed upon.

After developing legs and lungs, the tadpoles are called frogs. Frogs can leave the water in search of their food, which is very different from the aquatic plants eaten by tadpoles. Nearly every animal small enough to be eaten is a potential food for the frogs that wait motionlessly for the prey to pass or fly by.

Frogs, like eggs and tadpoles, are a food source for many different kinds of predators. Predation, more than disease, accounts for the few frogs resulting from the hundreds of fertilized eggs produced by a single pair of parent frogs. In the wild as few as five frogs from every thousand eggs may survive to reproductive age. Snakes, raccoons, cats, rats, birds, and humans are some of the more common predators.

Environmental conditions are important to frogs. Changes in weather from year to year, sometimes unnoticed by humans, create severe difficulties for frogs and influence the availability of eggs. In a dry year frogs are weakened and may starve to death because of the shortage of insects, their primary food. (One person who raises frogs professionally mentioned that if only five frogs per hundred eggs survived in the SCIIS program, and if those frogs were released, the survival rate would be higher than in his natural ponds, where he could not control the frogs' food supply and predators.)

You may expect that more than fifty percent of your frog eggs, and more than seventy-five percent of your tadpoles, will die under classroom conditions. You can improve the odds considerably if you provide plenty of food and space for each tadpole. If you remove some tadpoles to other containers, those remaining in the classroom containers will survive longer and grow faster.

If you must kill a tadpole or frog, place it in a plastic bag along with some water and freeze the bag. Frogs' freezing to death is very common in nature. Later, discard the bag and contents in a waste container.

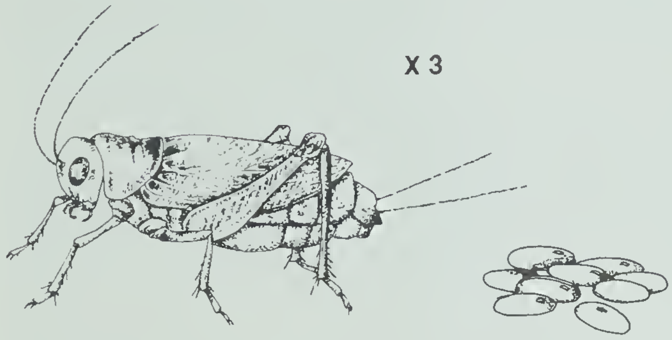
Cricket eggs.

Receiving the organisms. You will receive cricket eggs as part of Live Organisms Shipment LC-1. If the cricket eggs have shiny coats and do not appear to have been smashed, then you may assume that they are alive and well.

- Cricket eggs are shipped in soil, in a labeled container, and are moist when received.
- Open the container. You will notice cylindrical white objects about 2 mm in length; these are the cricket eggs. You should have received at least 150 eggs.
- If the soil looks dry, add a few drops of water from the container in which you are storing the frog eggs.
- Reseal the container. Store the eggs away from direct sunlight and excessive heat.
- About every two days until the eggs are used, remove the lid briefly to allow air circulation and to see if the soil needs any moisture.
- If the soil becomes moldy, water it less. The eggs will still hatch.

No other care is necessary. Of course, as with all SCIIS animals, it is important to get the animals to the children as quickly as possible. More animals are lost by being kept in one crowded container for too long a time than by being observed and handled by the children.

Figure L-2. Cricket eggs and adult.



Classroom care and maintenance. The following steps should be taken in caring for and maintaining cricket eggs and crickets:

- Keep the eggs moist at all times.
- Each egg must have access to air, because it is "breathing."
- The eggs are relatively resilient and can withstand some rolling around, but this should be kept to a minimum.
- There is little purpose to "storing" the extra eggs; distribute most of them to the children and put the rest in a container of your own. This will provide a reserve supply in case the eggs die in one of the children's setups.
- Knowing when the classroom eggs will hatch is valuable, and hatching time can be predicted. Take your container of eggs and soil home and position it near a source of heat. Regulate the temperature to about 32°C (90°F) by adjusting the distance between the eggs and the heat source. At that temperature, your eggs will hatch about a day before the children's eggs, which are being incubated at a lower temperature. Thus, you will be able to arrange the day's activities to allow for the hatching of the eggs. Encourage the children to examine their containers on the probable birthday of the crickets.
- Not all of the eggs will hatch. Some will have been injured in shipment, some will be injured by the children, and some may have dried out. In some cases, the eggs laid by the crickets would not have hatched in the outdoors either.
- Once the eggs have hatched, care should be taken to reduce the amount of water and humidity around the animals. Still, you must keep them inside closed containers to prevent their escape. Follow the directions in Chapter 10 and keep the soil farily dry. Use small quantities of the food provided for this unit. Be sure that the food does not decay. Decayed food is a sign of too much moisture and is not healthy for the crickets or for humans.

Description and natural history. Crickets are insects. The house crickets used in this unit typically live in dry, wooden frame structures rather than in fields. As they mature, you will note that they are brown. Most of the wild crickets you see are black field crickets.

A female cricket pushes her ovipositor (egg-laying tube) into moist soil and gradually squeezes out an egg. Each egg is about 2 mm (about 1/16 in) in length and less than 1/2 mm in diameter. The eggs are creamy-white in color with a glossy look. Hundreds of eggs may be laid in this fashion by one cricket.

About eighteen days after the eggs are deposited by the female, the nymphs (juvenile forms) hatch. The temperature affects their development — a warm environment hastens it. The nymphs are white in color and only a little larger than the eggs from which they came. Depending on the background color they may be hard to find, but when you become accustomed to seeing them, they are easy to recognize, especially when moving.

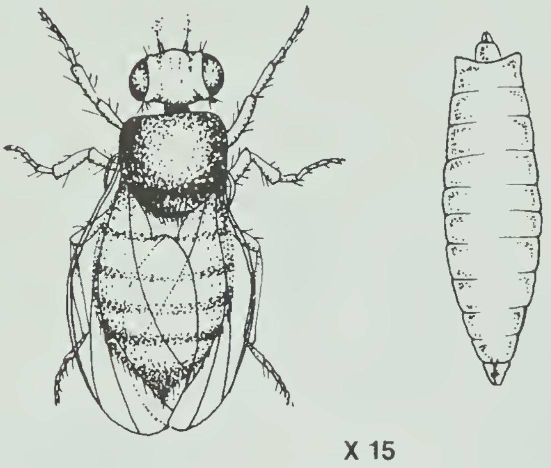
Disposal. Crickets are excellent food for frogs, toads, small snakes, and most lizards. Anyone who is teaching either *Populations* or *Communities* can probably use your extra crickets.

Fruit flies.

Receiving the organisms. With Live Organisms Shipment LC-2 you will receive twenty vials, each containing at least five adult fruit flies. The material at the bottom of the vials is food. It will last for about two complete life cycles, and so you will have no food problem with these animals.

Do not place the fruit flies in direct sunlight. Keep them at room temperature, or if you wish to speed up development and growth, place the vials in a warm place where the temperature does not exceed 30°C (86°F).

Figure L-3. Fruit fly larva and adult.



Classroom care and maintenance. The fruit fly vials require no care or maintenance. However, they should not be kept in direct sunlight or where the temperature might drop below freezing. Add a few drops of water if the cultures dry out.

The prepared food contains a chemical that inhibits growth of molds and bacteria. In spite of this, the food occasionally becomes contaminated. Molds will form a fuzzy growth over the top of the food, while bacterial colonies look like shiny spots. Dispose of vials that appear contaminated.

Description and natural history. This fruit fly is a wild variety of fruit fly found throughout the United States. Fruit flies are small insects that often are found associated with fungi and decaying fruit. They can live, grow, mate, and produce young even when kept in small vials containing prepared food.

Development of fruit flies consists of four distinct stages: egg, larva, pupa, and adult. The eggs are less than 2 mm (1/16 in) in length and are somewhat difficult to see; but the larvae, pupae, and adults are larger and the differences between them distinct. A day or so after an egg is laid, it hatches into a white wormlike larva. The newly hatched larva is quite small, but it grows rapidly and is easy to observe as it crawls about. After about five days, the larva changes into a pupa, which attaches itself to some object — in this case to the side or cap of the vial. A yellow case that corresponds to the cocoon of a moth encloses the fruit fly pupa. Within five to seven days, the pupa changes into an adult fly and emerges from the pupal case. The adult males and females mate within a day or so, the female lays eggs, and new individuals begin their life cycles.

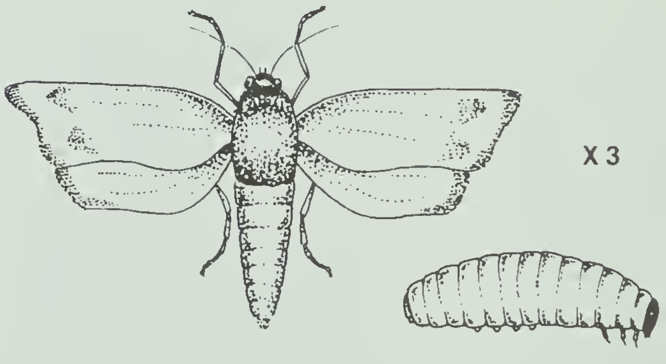
Disposal. To dispose of this animal, freeze the vials containing the flies; then either discard the vials and contents or wash the vials with hot water and save them for additional experiments.

Wax moth larvae.

Receiving the organisms. You will receive paper tubs containing about 100 wax moth larvae in Live Organisms Shipment LC-2, which must be ordered *three weeks* before the date on which you want to begin to use the animals. The larva are about 3–13 mm (⅛ – ½ in) long and are golden in color, and will usually be hidden inside the ball of food in each container. Do not bother trying to count them — it is too difficult. Carefully probe the food and try to see the larvae. If you see quite a few, assume they are all there and that they are healthy and well.

Once you find the animals and determine that they are healthy (as evidenced by active movement) little care or special treatment is necessary other than opening the containers every two days to allow fresh air to enter. Like all SCIIS animals, these should be distributed to the children as soon as possible, because there is less likelihood of total loss if the animals are spread around in different containers and not confined to one "basket." One good dose of sunlight coming in the window an hour after you have left your room can mysteriously wipe out a culture by the next day, and you may never realize why it happened.

Figure L-4. Wax moth larva and adult.



Classroom care and maintenance. These animals require almost no care. Once the food has been provided, it is necessary to make certain that the animals are neither placed in direct sunlight nor allowed to become too cold. If possible, maintain a temperature of 30°C (86°F) for the most rapid development. Do not let the temperature drop below 18°C (65°F) or rise above 36°C (97°F). Development and growth at 18°C will be very slow but will not result in the death of the animals. Open the container to allow air circulation every two days.

The food will become slightly discolored with time. Do not be concerned about this, but do examine it occasionally to see that the larvae have not eaten all of it, leaving only some greasy threads and waste matter that may look like food. If the food is used up, add some more. Never add water to this system, however dry the food appears to be.

Distribute the organisms to the children as soon as possible.

Description and natural history. The wax moth, *Galleria mellonella,* can be found almost everywhere humans live. It is not harmful to clothes or other household materials.

The female can lay up to 1,000 eggs; about ten days later, the eggs hatch into very small larvae which are mobile and can hunt for food. The eggs contain little food, and the larvae need food as soon as they develop. The food you receive is a mixture of mixed baby cereal (454 gr, 1 lb), glycerin (170 ml, ¾ cup), sugar (114 ml, ½ cup), water (114 ml, ½ cup), and Deca-Vi-Sol babies' vitamins (0.6 ml, 25 drops) that are added *after* the glycerin, sugar, and water have been heated until clear and then cooled. Then the fluid is thoroughly mixed with the dry cereal.

The larvae eat day and night and thus grow quite rapidly. This rapid growth in length and size is easily observed by the children. The growing larva molts (sheds) its skin about eight times over a period of about thirty days, after which it develops into a pupa. The larva produces a silklike thread and wraps itself inside a cocoon. After a few days when it has completed the inside of the cocoon, the larva's skin becomes quite hard and waterproof. The animal is now a pupa.

Enormous changes take place in the pupa, yet it appears inactive because we cannot see into the cocoon or the pupa case. Complete transformation from pupa to adult requires about twelve days, depending upon the temperature. (Warmer temperatures cause more rapid development.) The adult moth, which is about 15 mm (½ in) long, has a red spot on the head and a brown body and wings. Within ten days after becoming an adult the moth mates, completing a single life cycle. This process continues as long as there is adequate food and air available to the moths.

Disposal. The adult moths and the larvae may be fed to other small animals, such as lizards, frogs, toads, and spiders.

If you have no such use for the various life cycle stages of the moth, collect them in a bag, freeze them, and discard in a waste container. Do not let these animals loose, because they may invade a bee colony and eat the beeswax combs.

Mealworm larvae.

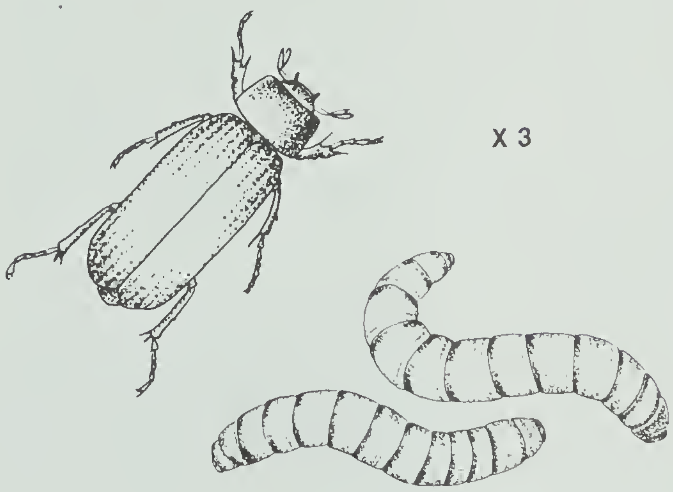
Receiving the organisms. You will receive about 225 mealworm larvae—half large and half medium in size in Live Organisms Shipment LC-3. Open the container and examine the culture to see if the larvae are moving and appear healthy. This process also lets fresh air into the container. Plan to distribute the mealworms to the children as soon as possible.

If you cannot give these animals to the children soon, provide some moisture by adding a piece of apple or potato to the shipment. Check every other day to allow fresh air into the container and to determine if the apple or potato has become moldy. If mold does appear, remove the moldy materials, add a new potato or an apple, and remove the container top. Cover the container with a porous piece of fabric, such as a dish towel or T-shirt.

After you have distributed most of the animals to the children for their activities, add a little of the mealworm food to your cultures. Keep your own culture going as a reserve for new children or for children who have accidents with their animals.

To prepare a classroom culture of mealworms, use one of the 6-liter plastic containers. You will not need the lid. Pour in all the mealworm food you have available, until the container is up to ¾ full. Add all the mealworms and the food in which they were shipped. Lay about ten paper towels across the top of the food, making sure that none of the towels provide a pathway for the mealworms to the top of the container rim. Using the SCIIS water sprinkler, spray about three long squirts of water onto the top towels, allowing the water to soak into the towels but not into the food. Within a day or two, place two or three potato sections just under the towels. Thereafter, keep the top towels wet by spraying them with a squirt every

Figure L-5. Mealworm larvae and adult.



other day or so. (The lowermost towels should be only damp.) Whenever you need mealworms, you will probably find the larger ones in the top few layers of the towels; the smaller ones can be found in the food. Later on you will have pupas, adults, and eggs in the culture as well as larvae.

Classroom care and maintenance. The following procedures are suggested for the care of mealworms:

- Maintain just enough moisture for the animals to remain active and healthy looking — not so much that it causes mold or decayed food.
- Supply enough food so that the animals will have more than they need at all times.
- Protect them from direct sunlight.
- If kept at a temperature of 26°C (80°F) or more, the animals will develop and grow faster than at lower temperatures.
- Your classroom culture should be at least 15 cm (6 in) deep. Select a container such as a coffee can, which will provide darkness and depth without requiring massive quantities of food. Keep a moist paper towel on top of the food and cover the can with a cloth held in place by a rubber band.
- If you see any brown or black larvae, they probably have a disease. Dispose of those larvae; the others will probably be unaffected.

Description and natural history. Mealworms, *Tenebrio molitor*, are varying shades of cream in color, are 5–15 mm (¼–⅝ in) in length, and have six legs. They, like some of the other animals we use, belong to the class Insecta. They undergo four distinct life cycle stages, but spend most of their lives as larvae.

Mealworms are most commonly used for fish bait and for feeding small pets, such as lizards, turtles, and frogs. They eat bran and other grain.

The life cycle of the mealworm in a warm environment (21°C, or 70°F) lasts about three or four months. Eggs do not develop into larvae for about 6 days; the larvae require about 60–120 days to pupate; and the pupae usually become adults after about 10 days.

The adult beetles are white when they first emerge, become brown later, and then turn black. Both the larvae and the adult will take moisture from apples, potatoes, moist towels, and other materials. The adult must have some moisture available to it, though the larvae can survive without access to moisture. Adult males and females may be seen mating. The female will lay eggs soon afterward. These eggs are almost impossible to find.

Disposal. These animals may be used as food for small animals. Frogs, toads, lizards, and turtles will snap up both the larvae and adults. Pet stores will accept them, and of course they may be used as fish bait. Teachers of the SCIIS units *Populations, Environments*, and *Communities* can use your extra mealworms.

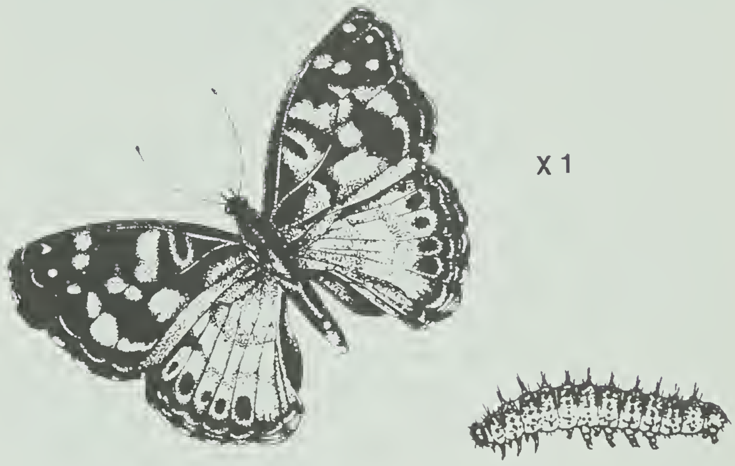
Butterfly larvae.

Receiving the organisms. You will receive about five butterfly larvae and one dark layer of food in each of two plastic cups. Open the containers and gently touch each larva with a stick to see if it moves. (The larvae will not get out.) Unless more than two larvae are dead, do not request a replacement shipment.

You will probably receive larvae of the Painted Lady butterfly. In some cases, the similar Buckeye butterfly will be sent instead, but it will behave in much the same way. For your information, the identity of the butterfly you receive will accompany the shipment.

Set up the two butterfly houses. Distribute the larvae (caterpillars) to the children after telling them to handle the animals gently. Then have the children put five larvae in each of the shipping containers. Replace the paper disk and the top and store the containers in the butterfly house. Until the larvae pupate, they must spend most of their time eating, inside the small containers.

Figure L-6. Painted Lady butterfly and larva.



Classroom care and maintenance. Two days after the larvae pupate (form chrysalids), remove the papers with the chrysalids attached from the two plastic cups. Put a stick in each house and suspend the papers from the sticks. Add a few more twigs to each house, being sure they lean against the sides rather than lying flat. The adult butterflies will alight on these twigs and small branches.

Feeding the larvae is simple; just keep them on the prepared food that was shipped with the animals. The pupae do not eat. Feeding the adults is a little more complicated, but not difficult. Prepare a 5% solution of household sugar and water. A 5% solution is one part sugar to twenty parts water. (You may use teaspoons, tablespoons, milliliters, or any other convenient measure as long as you use the same units of measurement for both sugar and water.) If you want to store the extra sugar water, cap it and refrigerate it in order to avoid having it spoil and attract flies.

To feed the butterflies, half-fill each of two vials with the sugar solution and insert a rolled-up piece of paper towel 8 x 8 cm in size. The rolled end of the towel should be squeezed together and bent over at the top to prevent a butterfly from falling into the sugar solution. The towel will absorb the sugar water, acting as a wick, and the butterflies will be safe.

Use masking tape to attach each vial of food to the wall of a butterfly house so that it will not spill. Change the sugar water solution every two days to prevent spoilage.

Description and natural history The Painted Lady butterfly is one of the most common of all butterflies. It caterpillars feed on plants such as fiddleneck, nettle, and hollyhock; the adults feed on nectar from any flower. Like all butterflies, they are preyed on by birds.

Four distinct developmental stages occur from egg through adult. At room temperature this animal remains in the egg stage for four days, in the larvae stage for twelve to eighteen days, and in the pupa stage for about eight days. The adults mate and begin laying eggs within four days after they emerge from the pupal stage. You may have the good fortune to have mating and egg-laying occur in your butterfly houses, although you should not count on it.

Disposal. The adult butterflies will probably die soon. If it is necessary to kill any of them, freeze and discard them in plastic bags.

Design and Use of the Kit

The equipment kit has been designed to help you teach the unit effectively. Except as noted below, all materials needed for a class of thirty-two students have been included. The items are packaged for convenient removal, use, and reuse. In response to feedback from users of SCIS, we have placed a contents list on the front of each drawer. In addition, the chapter "Teaching Materials" lists are now arranged by drawer number.

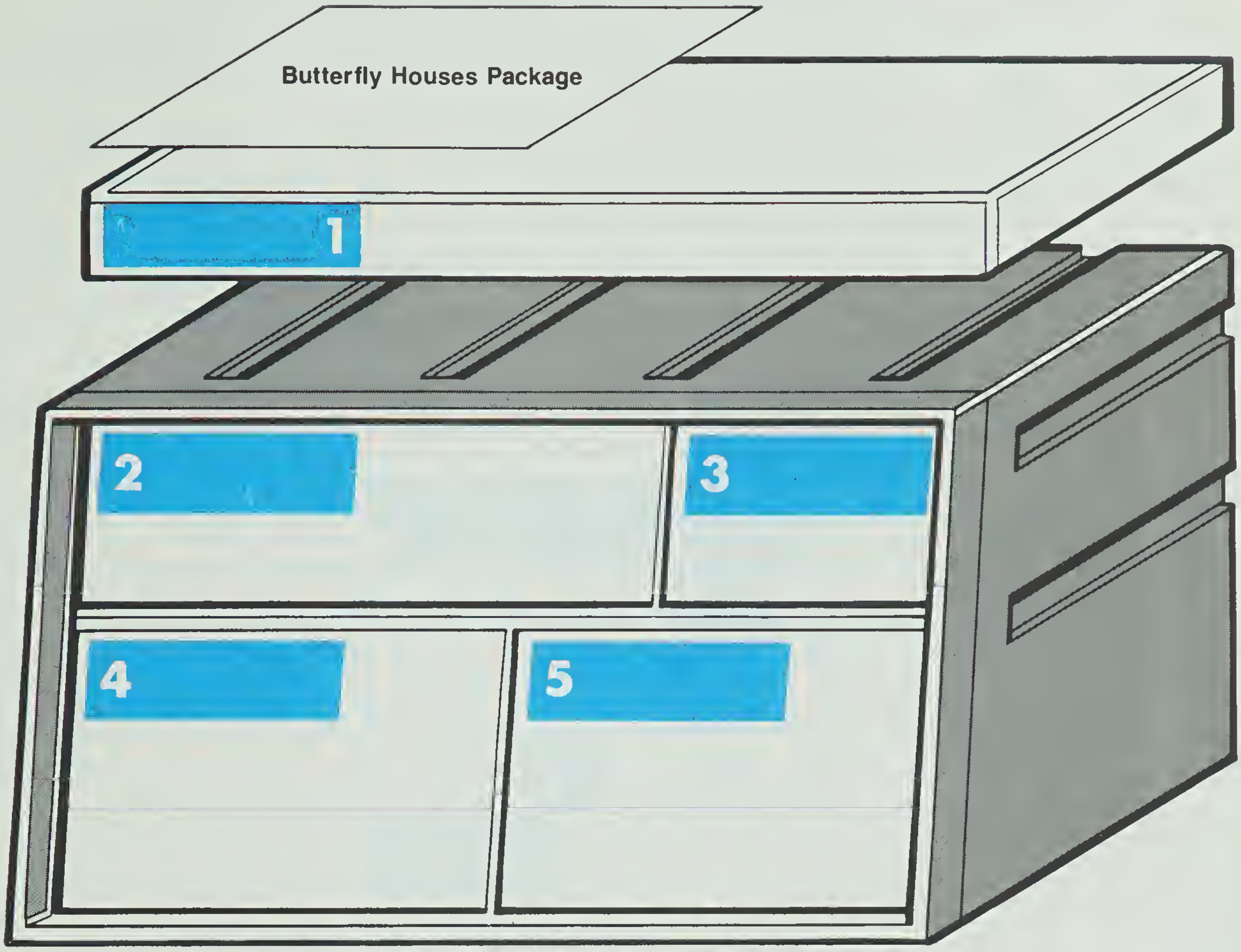
Familiarize yourself with the entire kit as well as with the diagram and lists on this page. You should inventory the kit before beginning to teach the unit, using the lists on this page for checkoff and notes.

Drawer 1, containing the printed materials, is a separate box. Place it on top of the kit as indicated in the diagram.

Some common items are to be provided by the teacher. The "Teaching Materials" list for each chapter indicates what you are to provide, and the "Getting Ready" notices give you advance warning about these items when necessary.

The live organisms studied in this unit are not included in the kit. Instead, they will be sent separately when your completed order forms are received. Complete directions for ordering are on page 106.

Drawer	Item Description and Quantity
1	1 Teacher's Guide
	32 student manuals
	2 sets of Extending Your Experience cards and display box
	1 evaluation envelope
	1 set Organisms game cards
	1 set Organisms cards
	1 set Habitat cards
	1 set Food Chain cards
	8 sort mats
	8 sets Plant and Animal cards
	1 Central Park gameboard
	1 set Plant Development cards
	36 Bean Plant student sheets
	36 Fruit Fly student sheets
	8 sets Life Cycle cards
	1 set Moth Development cards
2	50 sprigs air fern
	16 magnifiers
	16 trays
	3 planter bag supports (6 feet, 3 wire frames)
	1 light source
	16 cricket feeders
	1 set of Live Organisms Shipments order forms
3	75 small plastic zip lock bags
	1 box wire hooks
	64 plastic bags
	16 large plastic zip lock bags
	32 petri dishes
	2 plastic vials
4	34 tumblers
	16 tumbler lids
	4 large fluted containers
	2 dip nets
	38 small fluted containers



Drawer	Item Description and Quantity
5	45 planter cups
	45 planter bases
	6 water sprinklers
	4 packages bean seeds
	4 packages corn seeds
	2 packages pea seeds
	2 packages squash seeds
	2 packages radish seeds
	1 roll labels
	4 flowerpots
	1 box toothpicks
	16 metric rulers
	50 wooden sticks
	Separate package
	2 butterfly houses

Sand and Soil box

1	bag of soil
2	bags of vermiculite

Live Organisms Shipment LC-1

150	cricket eggs
100	frog eggs
1	container cricket food
1	container tadpole food

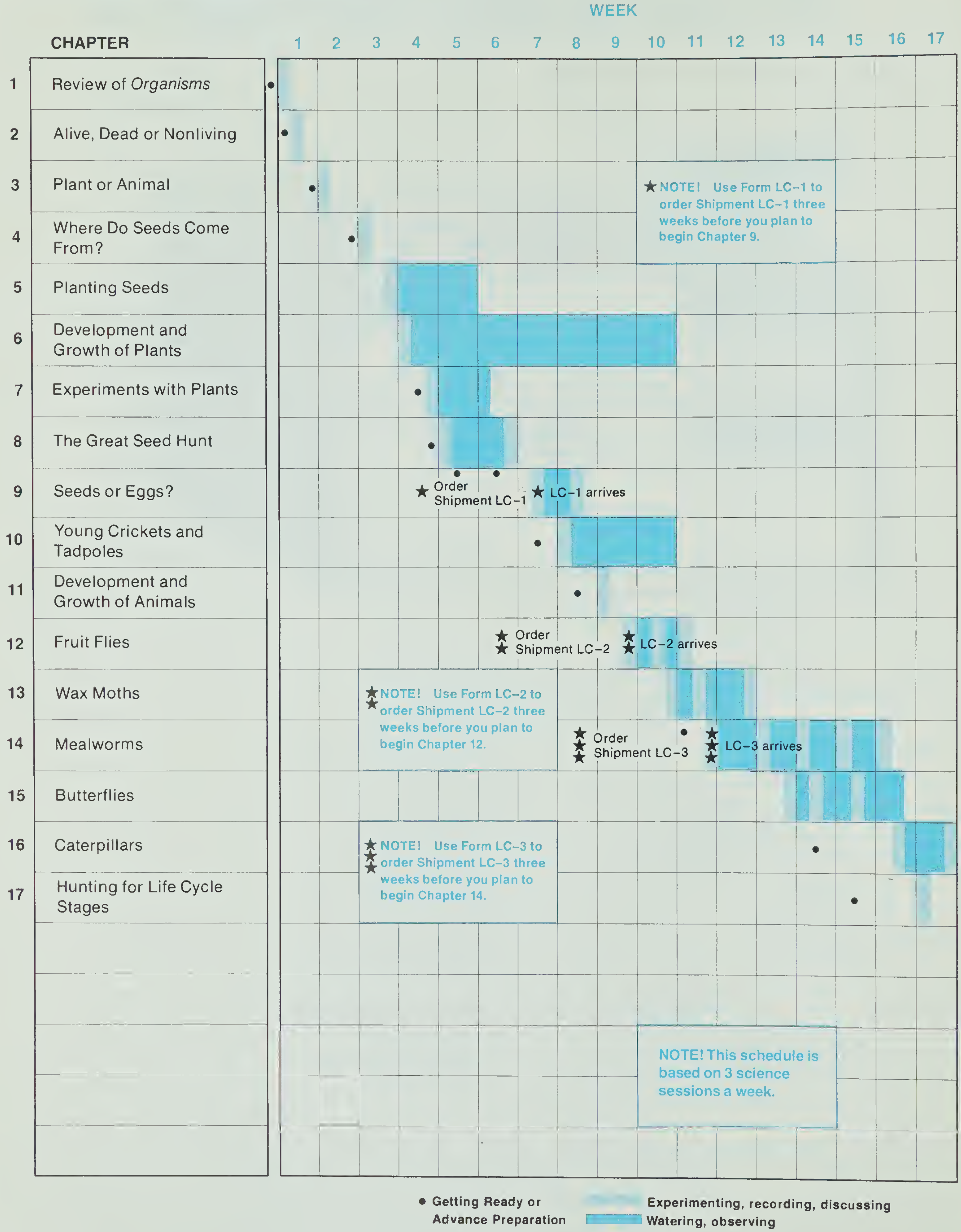
Live Organisms Shipment LC-2

20	capped vials of fruit flies
100	wax moth larvae
6	packages wax moth food

Live Organisms Shipment LC-3

250	mealworm larvae
1	package mealworm food
2	butterfly cultures

Life Cycles Schedule of Activities



★ NOTE! Use Form LC–1 to order Shipment LC–1 three weeks before you plan to begin Chapter 9.

★★ NOTE! Use Form LC–2 to order Shipment LC–2 three weeks before you plan to begin Chapter 12.

★★★ NOTE! Use Form LC–3 to order Shipment LC–3 three weeks before you plan to begin Chapter 14.

NOTE! This schedule is based on 3 science sessions a week.

● Getting Ready or Advance Preparation

Experimenting, recording, discussing

Watering, observing

DATE DUE SLIP

DUE EDUC NOV 03 '89	
OCT 26 RETURN	
EDUC NOV 19 '89	

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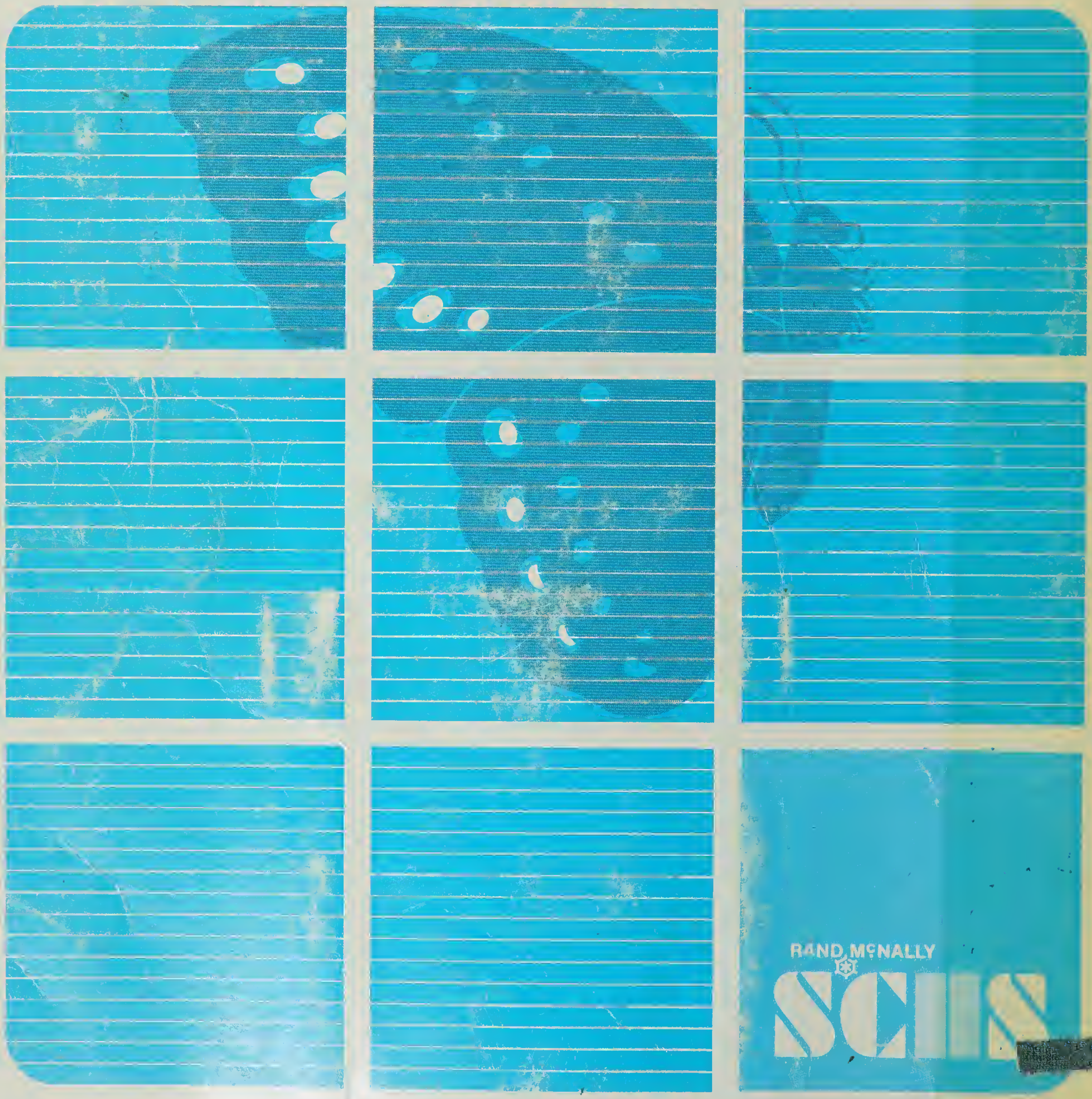

RAND McNALLY
SCIIS